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(54) **ELLIPTICAL EXERCISE DEVICE AND METHODS OF USE**

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(58) **Field of Classification Search** 482/51, 482/52, 53, 57, 70
See application file for complete search history.

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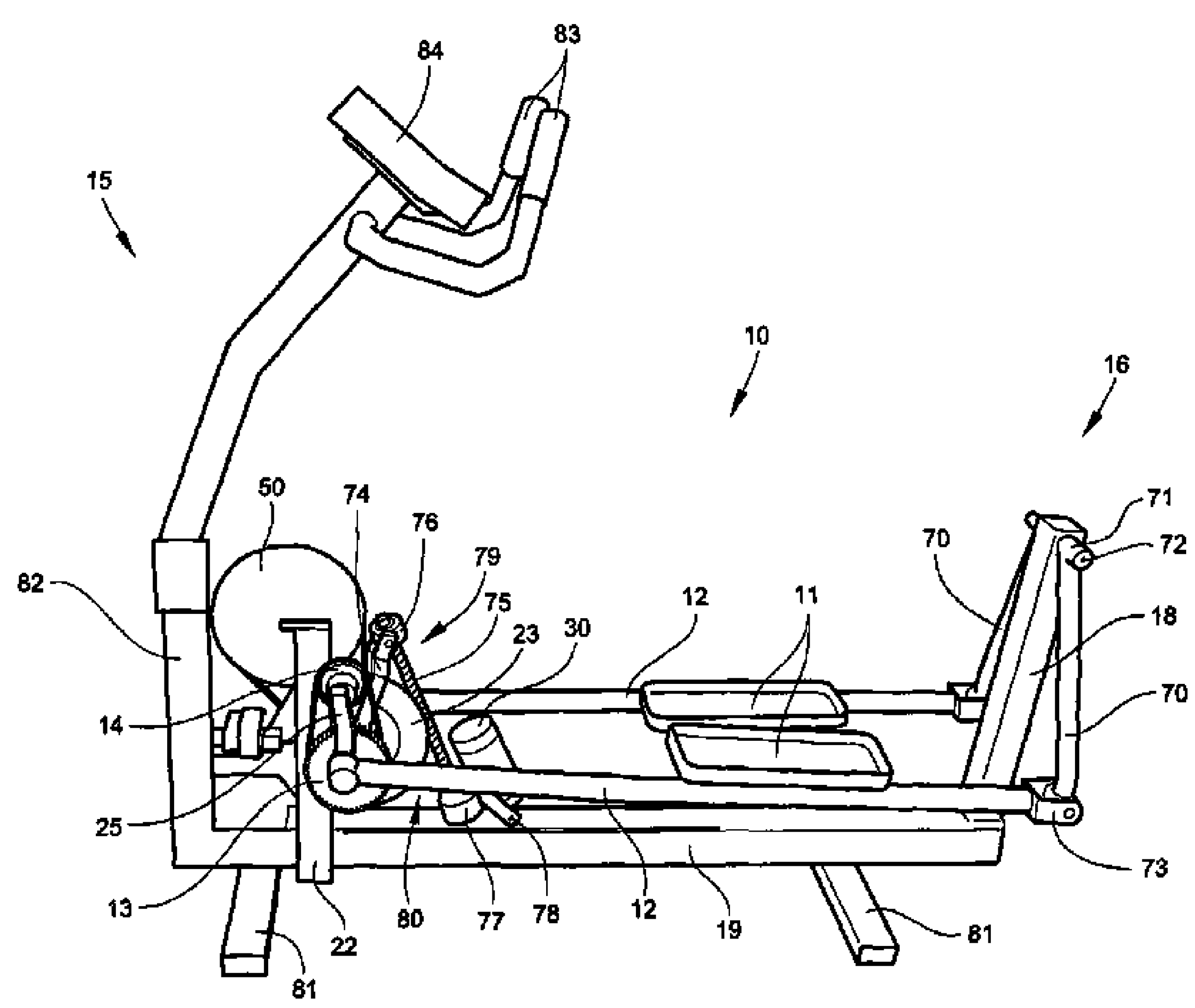
(57) **ABSTRACT**

An exercise device can include a pair of pedal members, each of which can be rotatably connected on at least one end to a planet gear that is rotatable about a sun gear on each side of the device. The pedal members and the planet gears can be rotated to provide an elliptical exercise motion. The device can include a mechanism for simultaneously rotating each of the sun gears together to change the orientation of the elliptical exercise motion relative to a user. The orientation of an elliptical exercise motion can be changed dynamically from one orientation to another, for example, from horizontal to uphill or downhill, during a particular workout period. The exercise device can change the orientation of an elliptical exercise motion while maintaining a user's ankles at a substantially constant angle during the exercise cycle.

8 Claims, 8 Drawing Sheets



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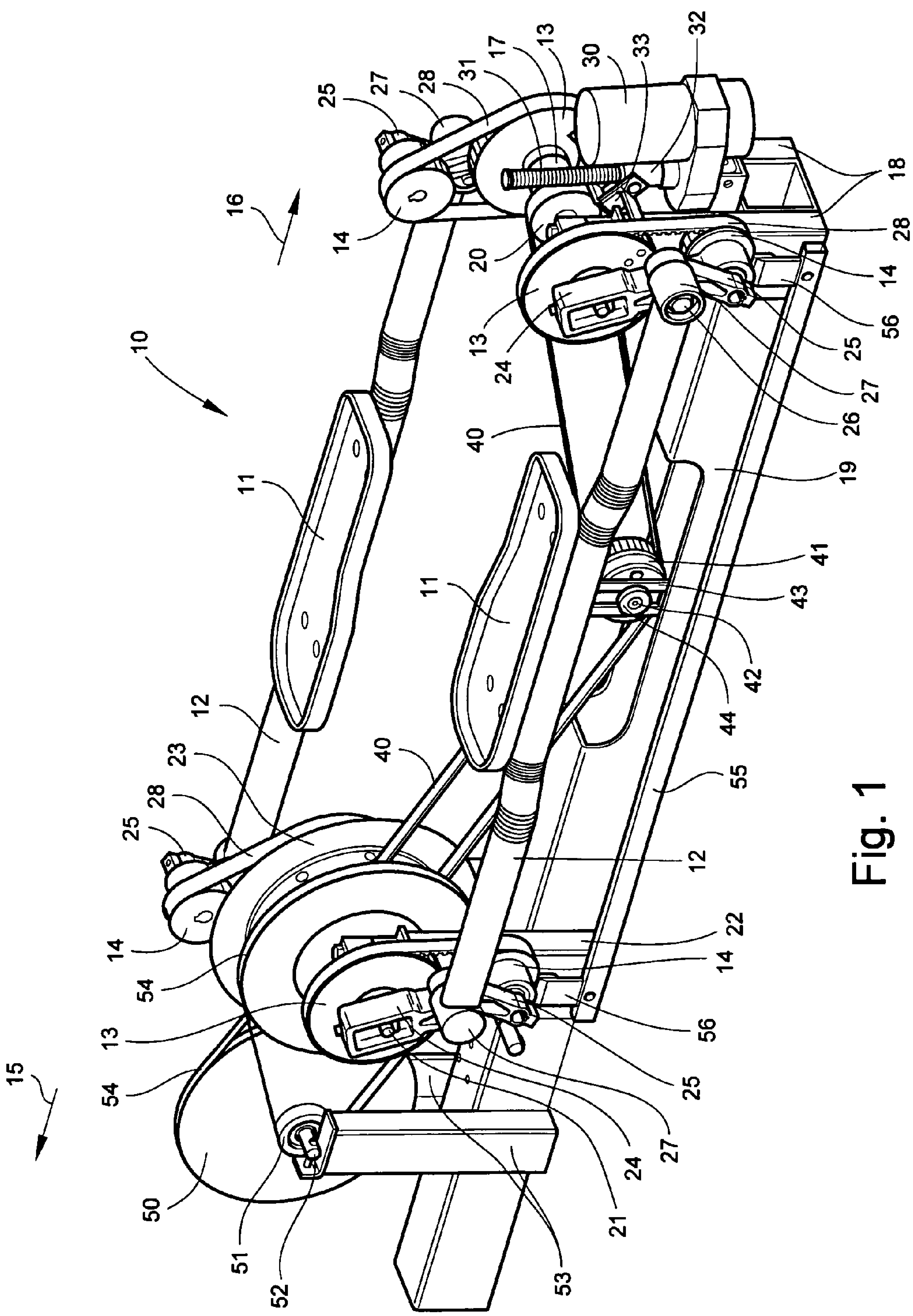
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Fig. 1

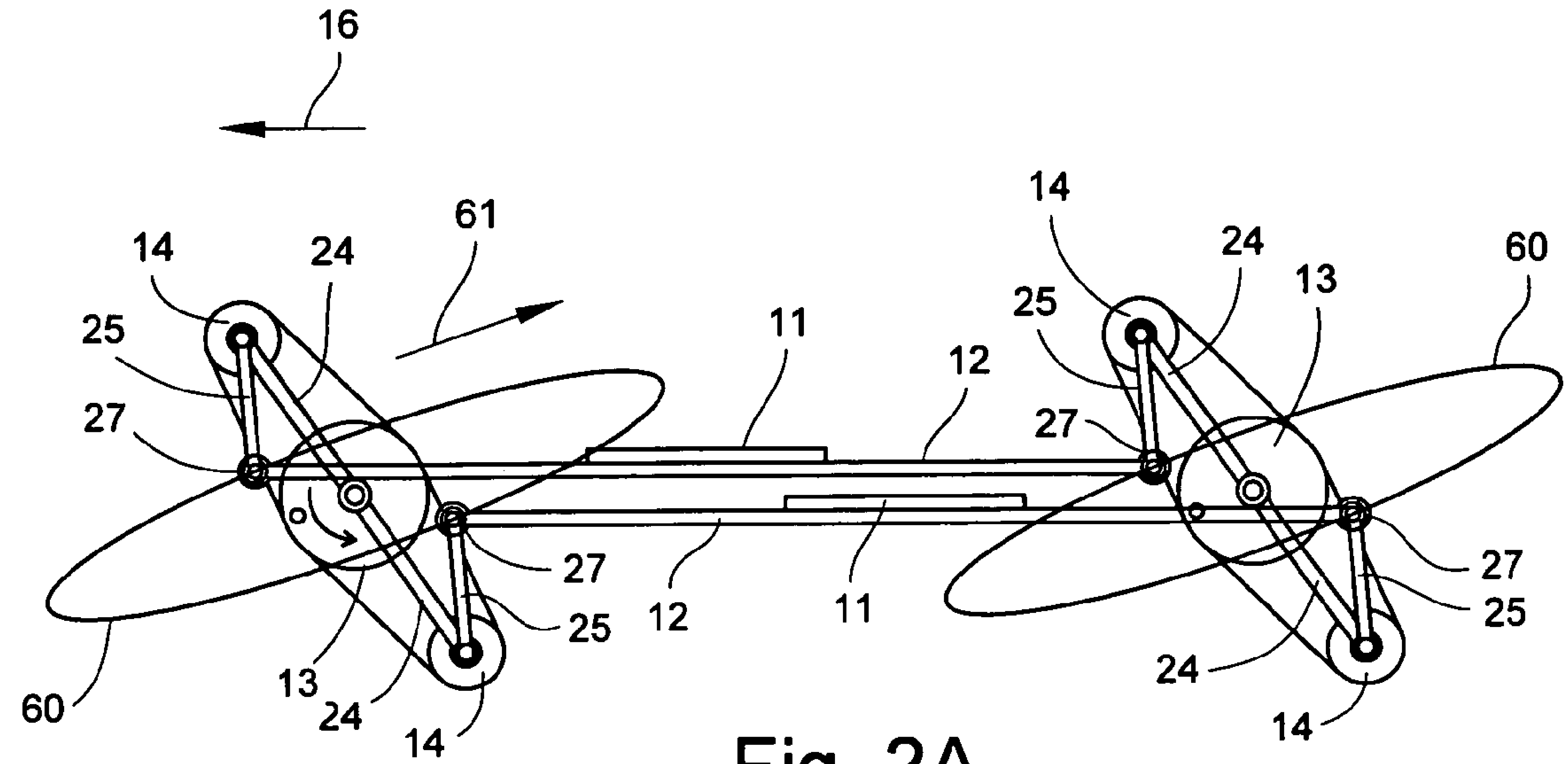

Fig. 2A

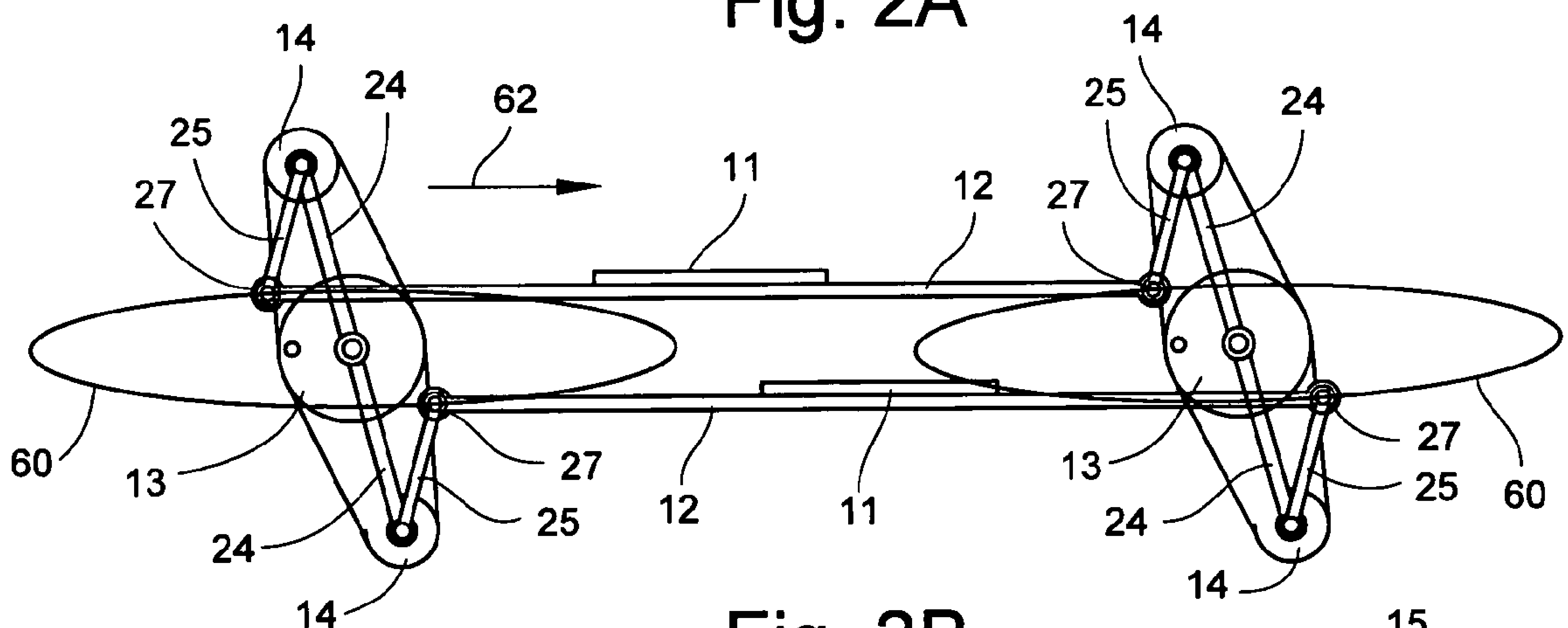

Fig. 2B

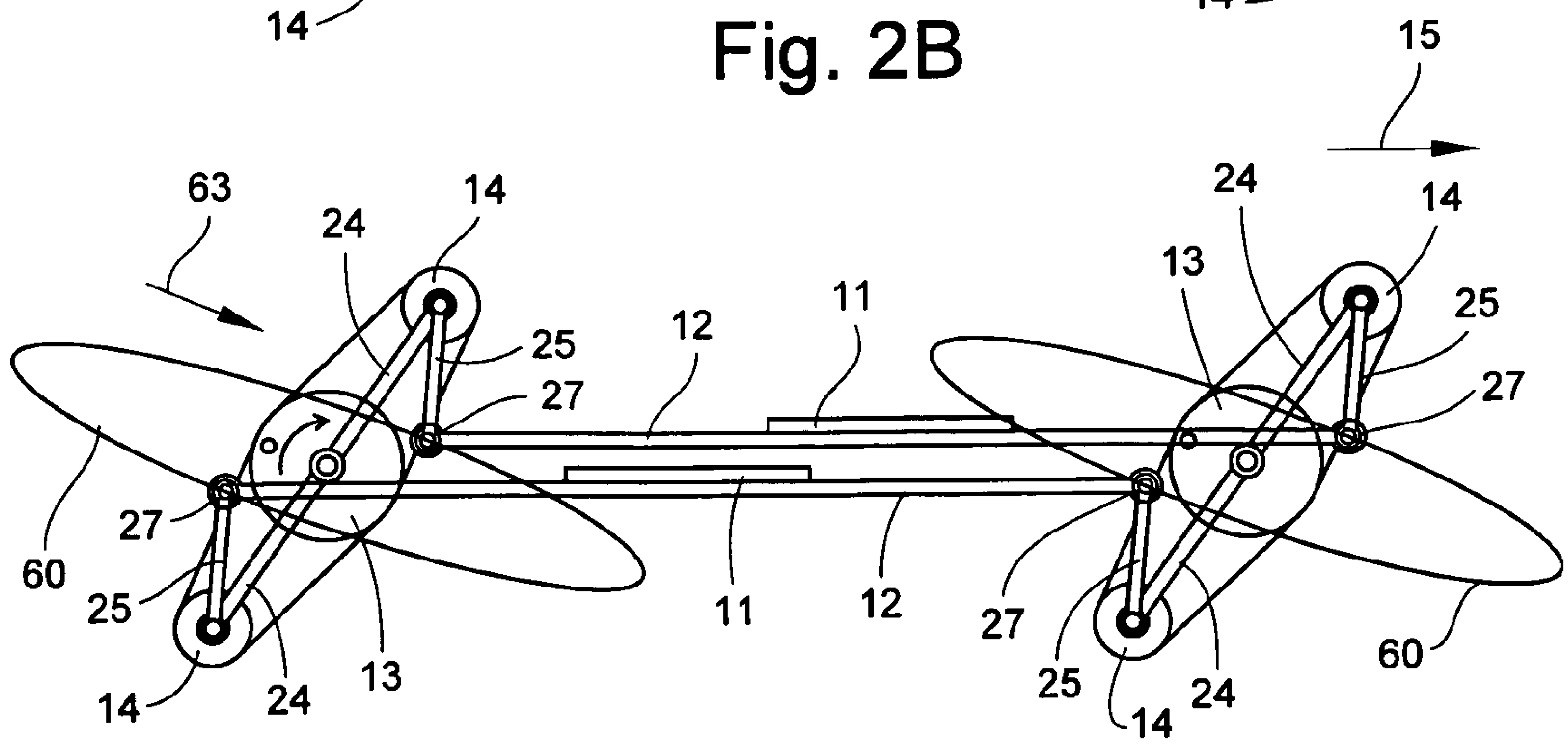

Fig. 2C

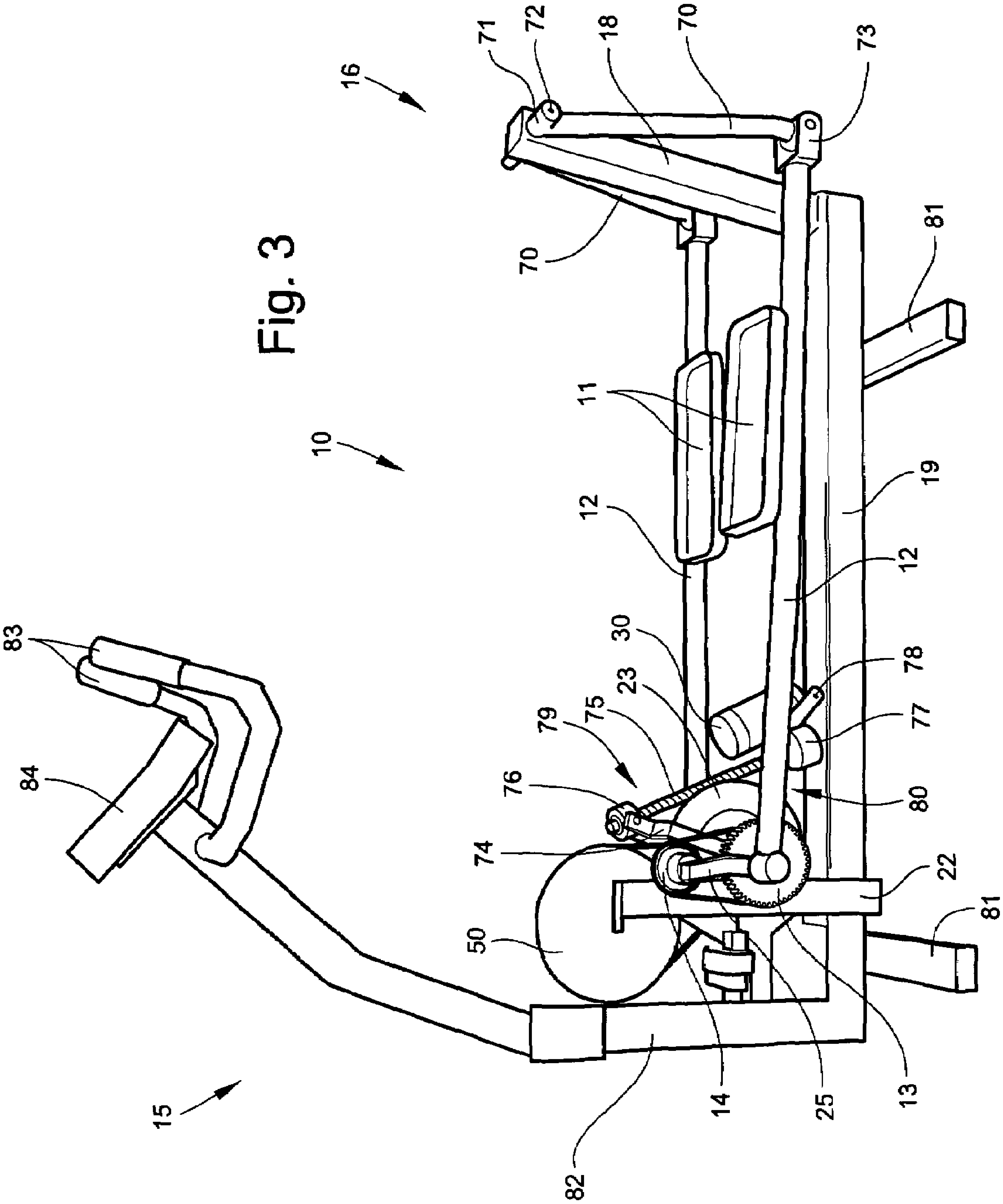

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Fig. 3

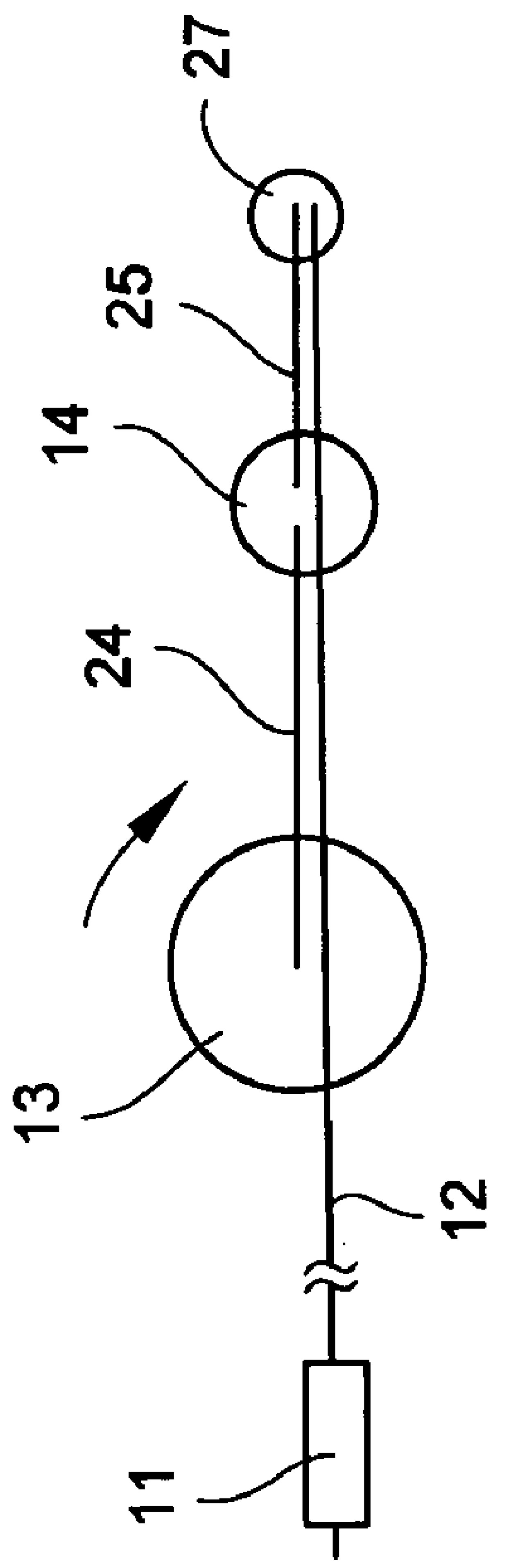

Fig. 4A

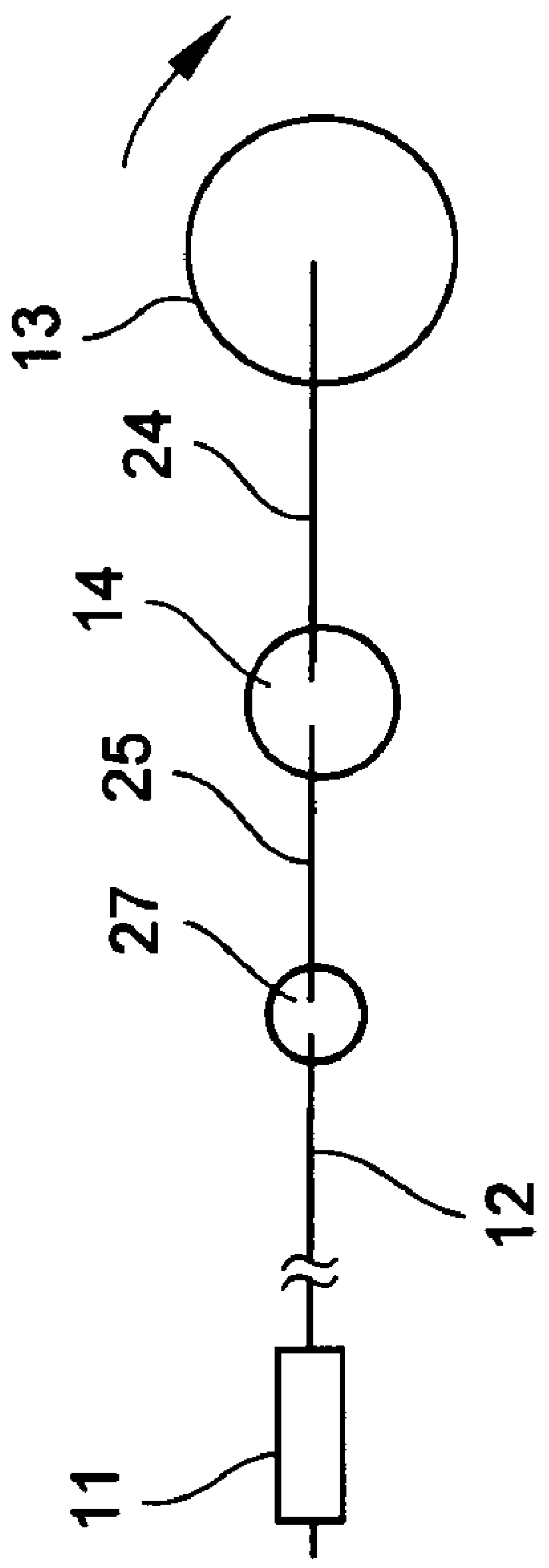

Fig. 4B

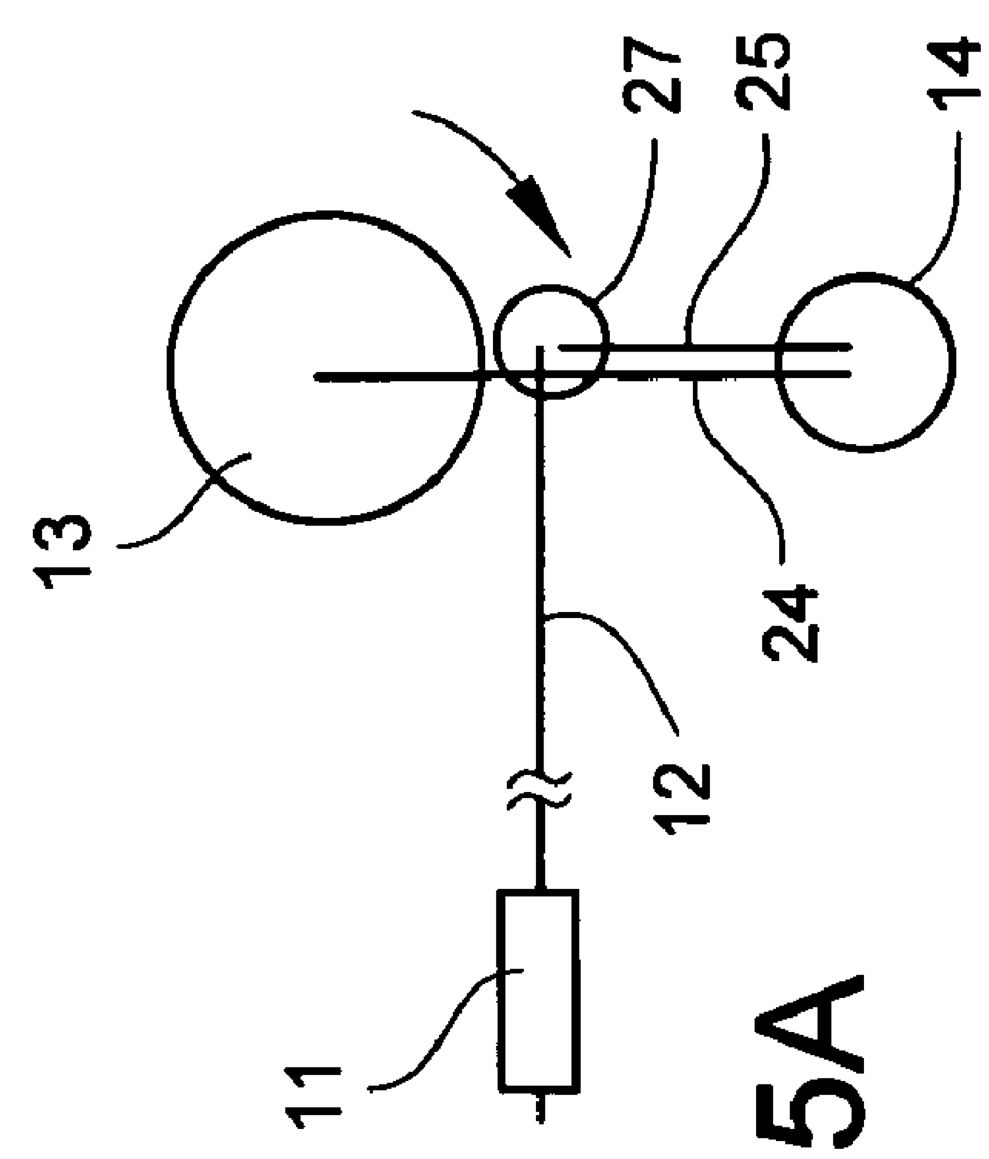

Fig. 5A

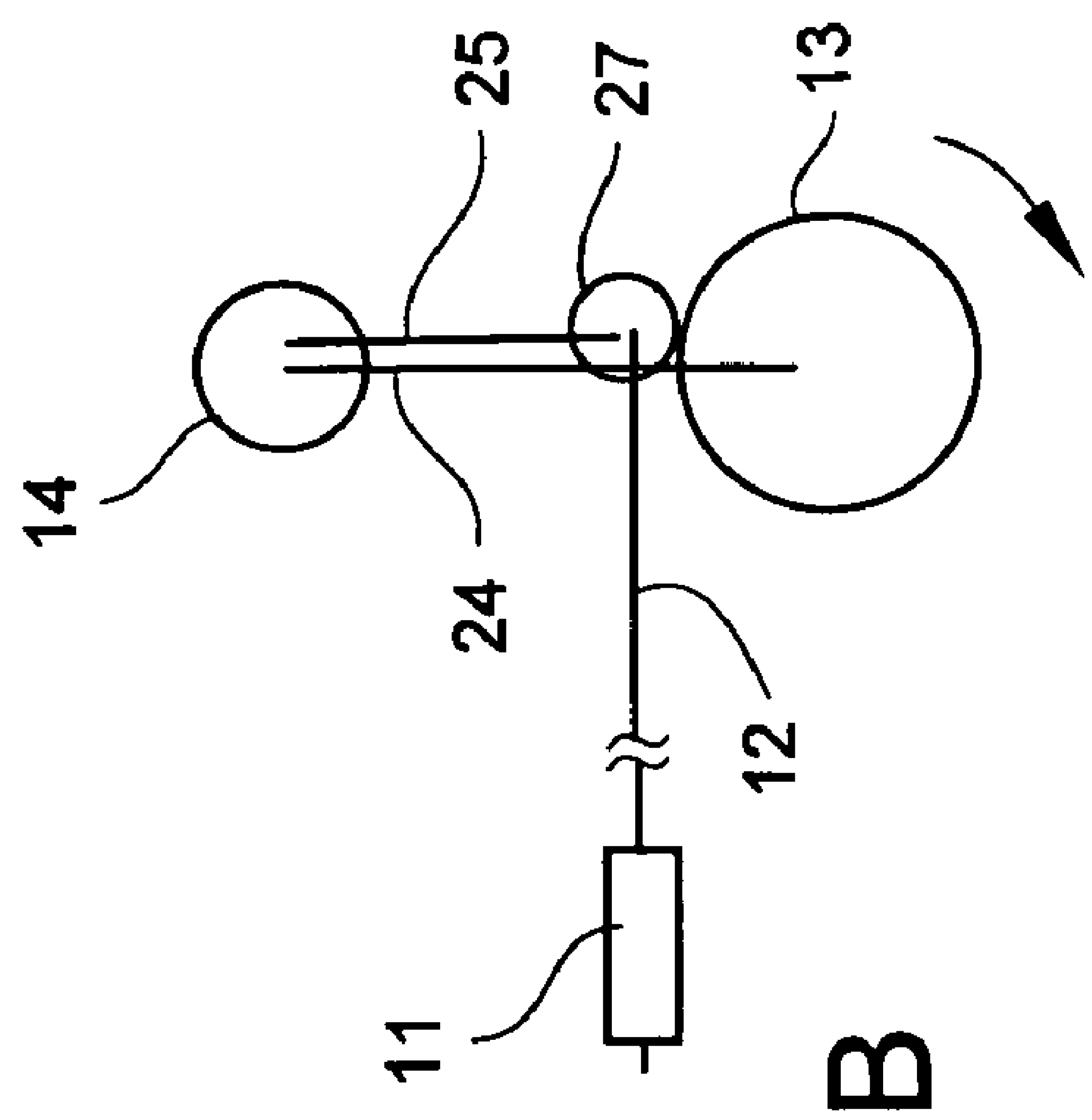

Fig. 5B

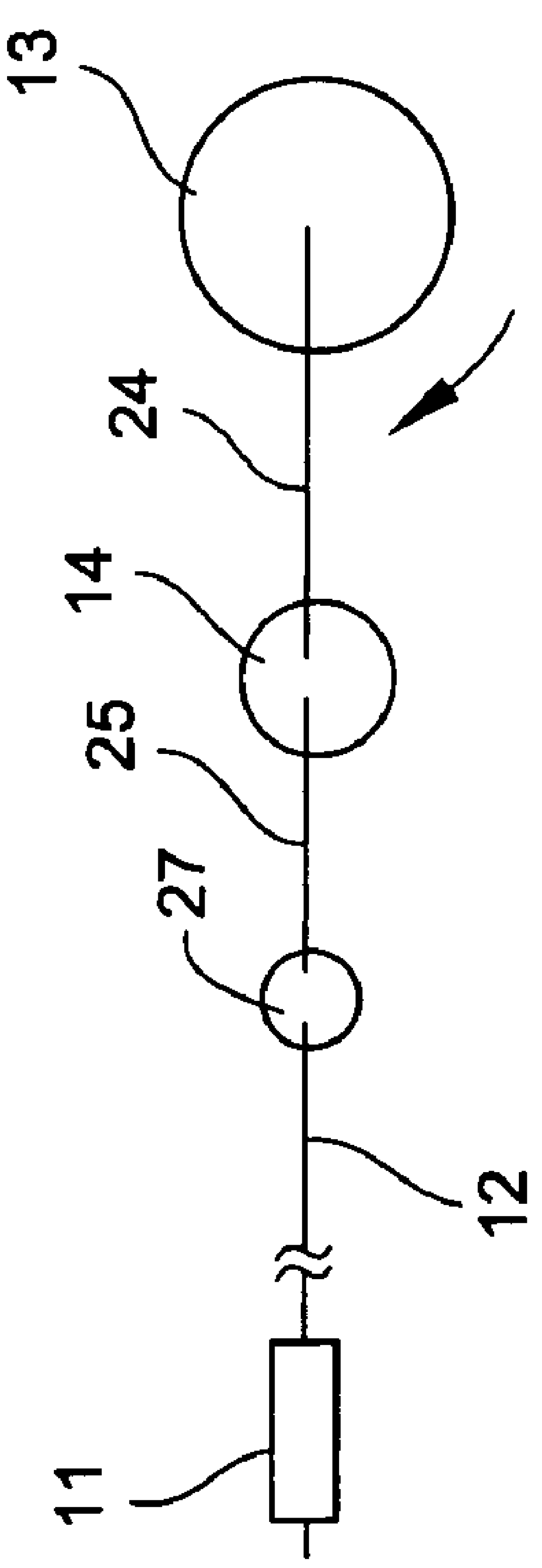

Fig. 6A

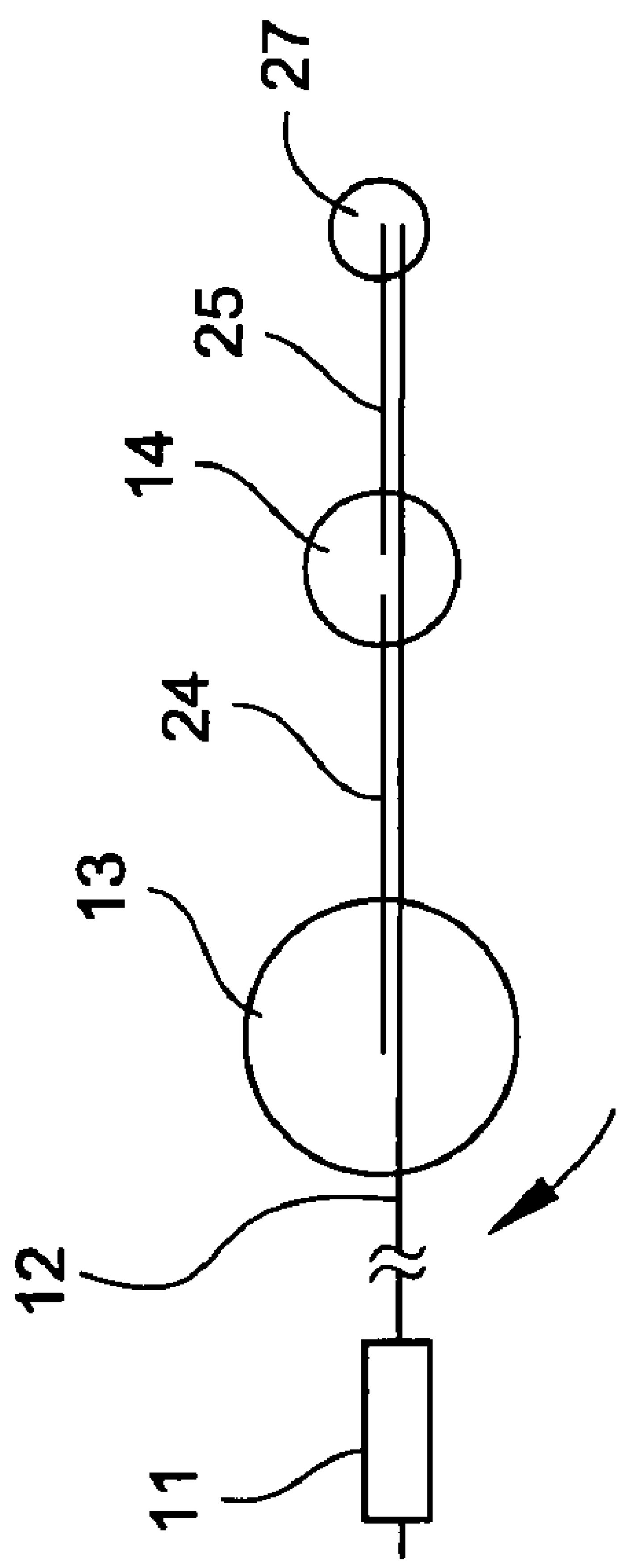

Fig. 6B

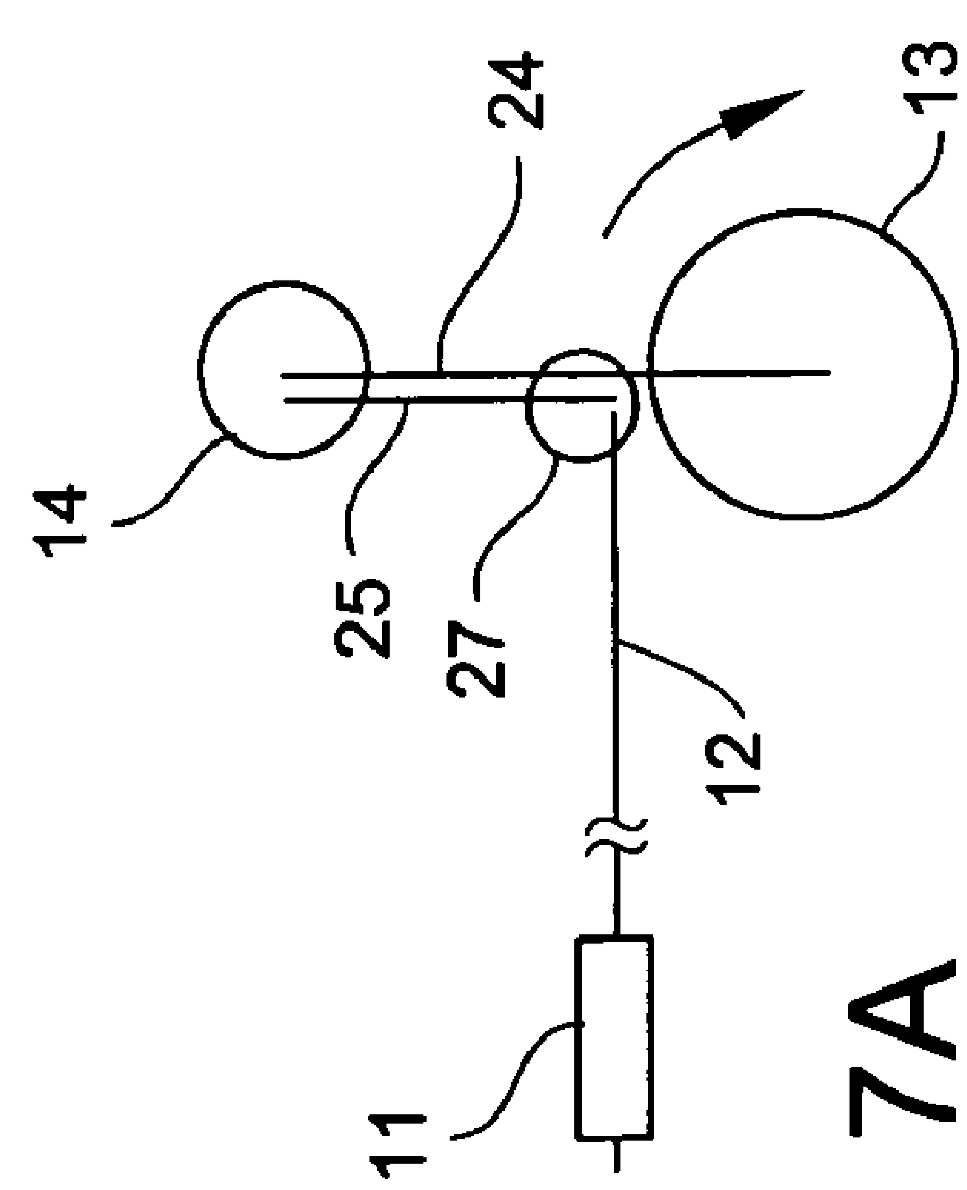

Fig. 7A

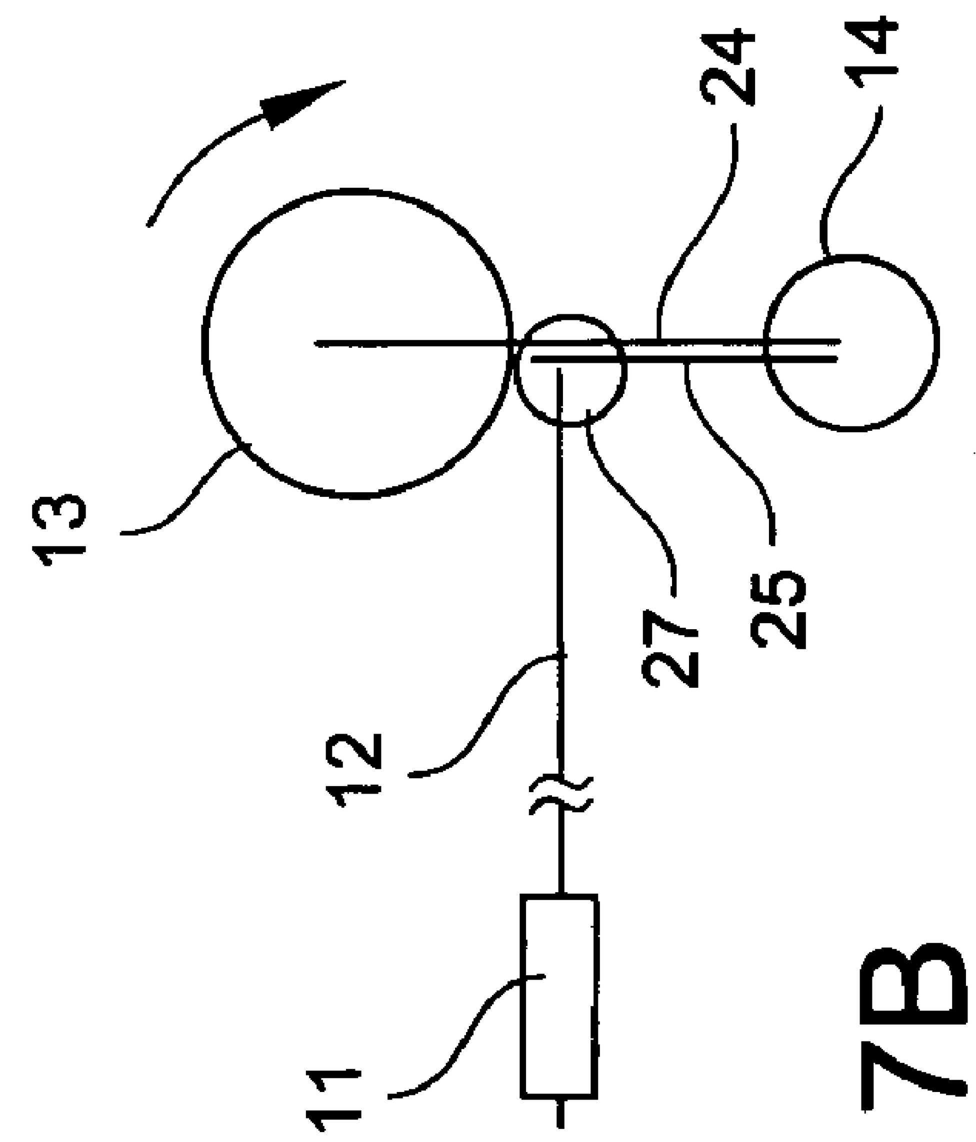

Fig. 7B

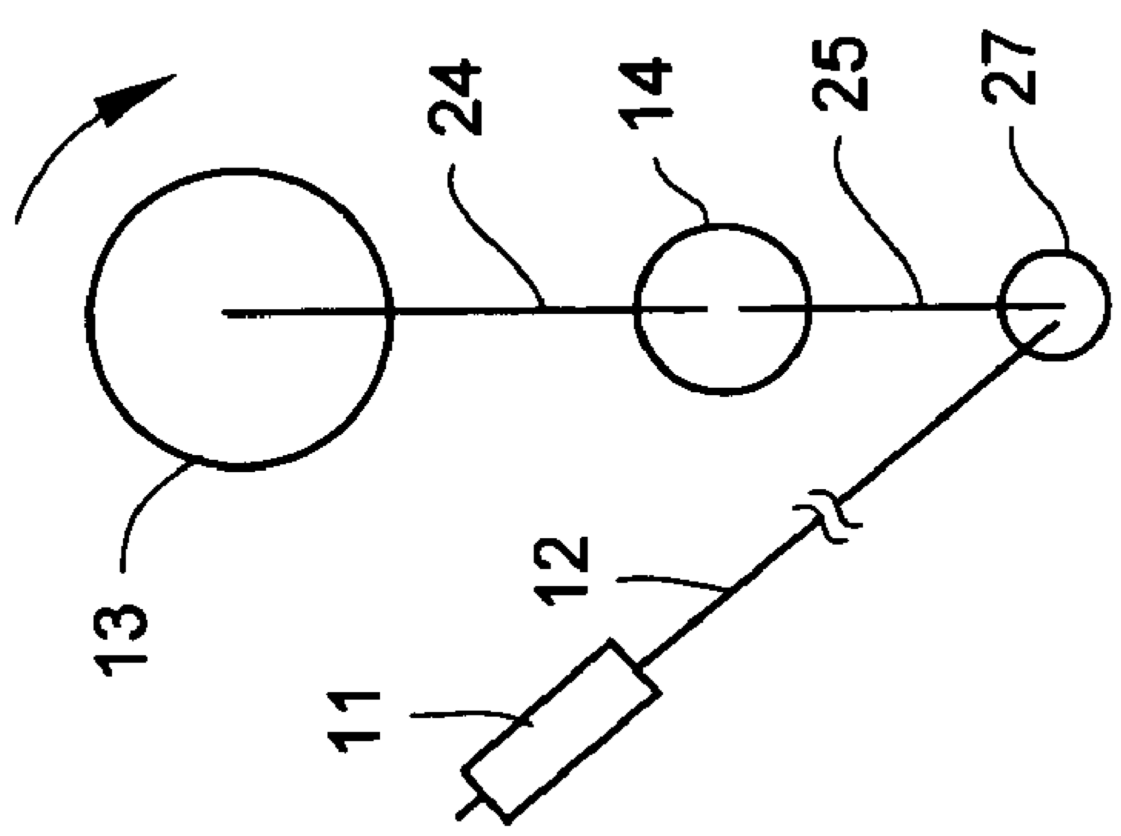

Fig. 8A

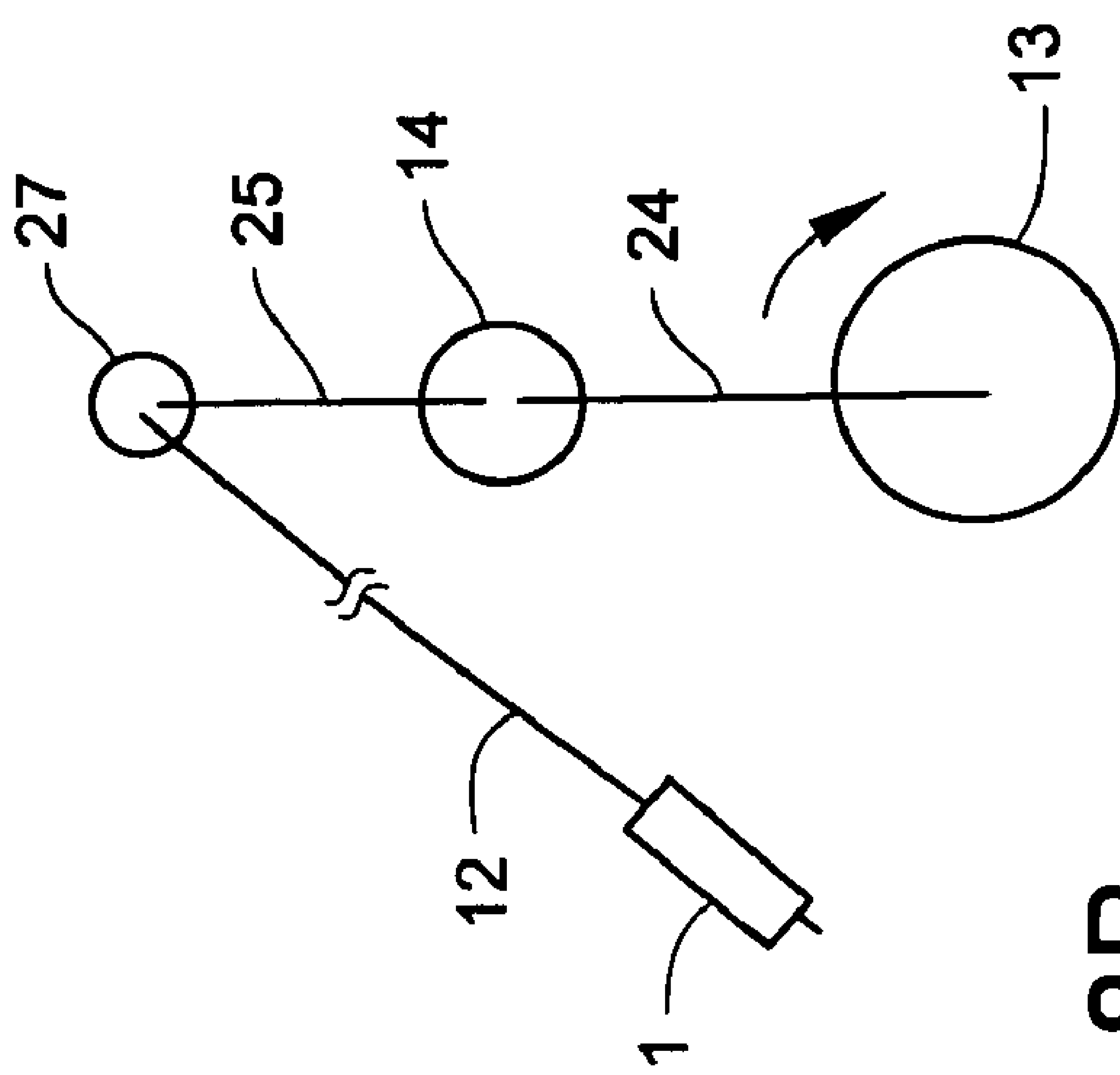

Fig. 8B

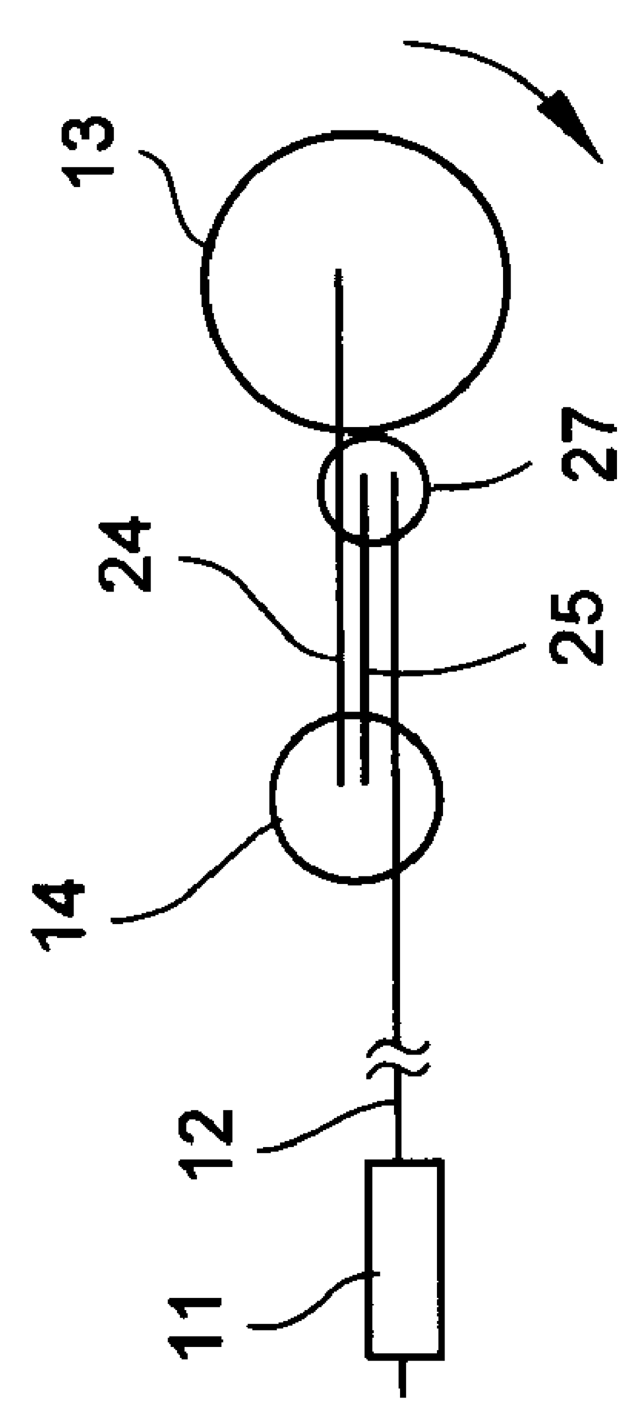

Fig. 9A

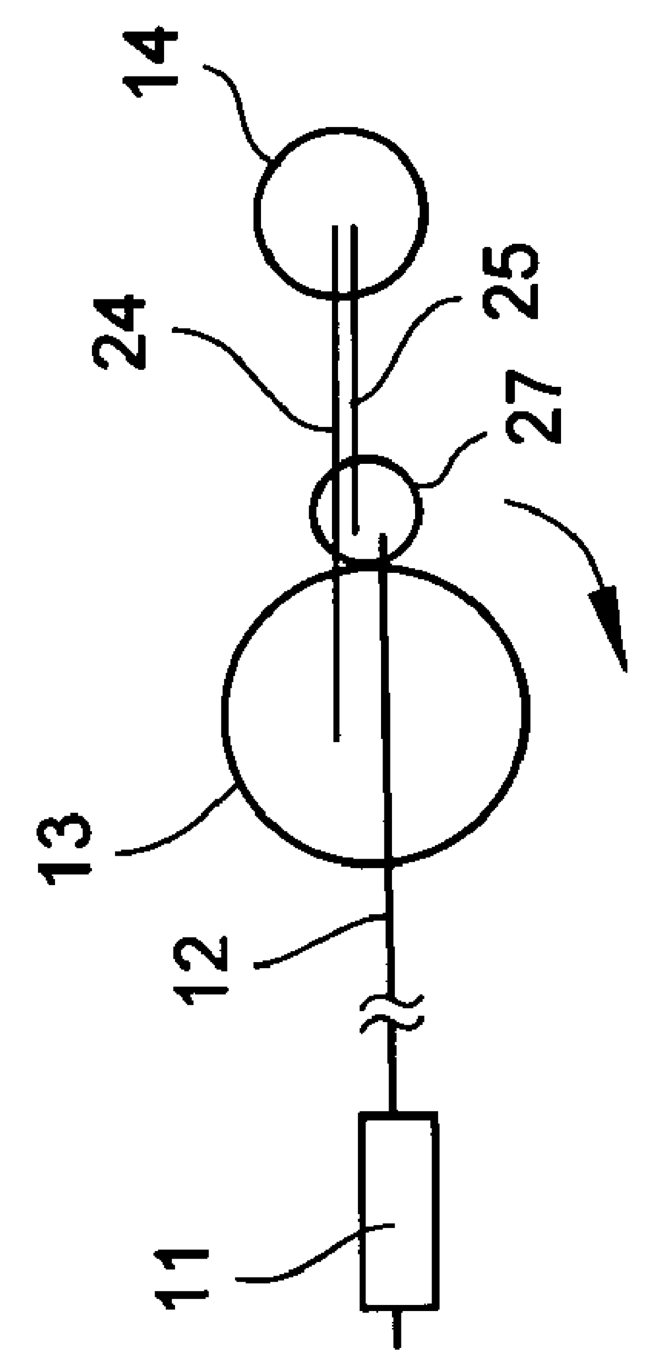

Fig. 9B

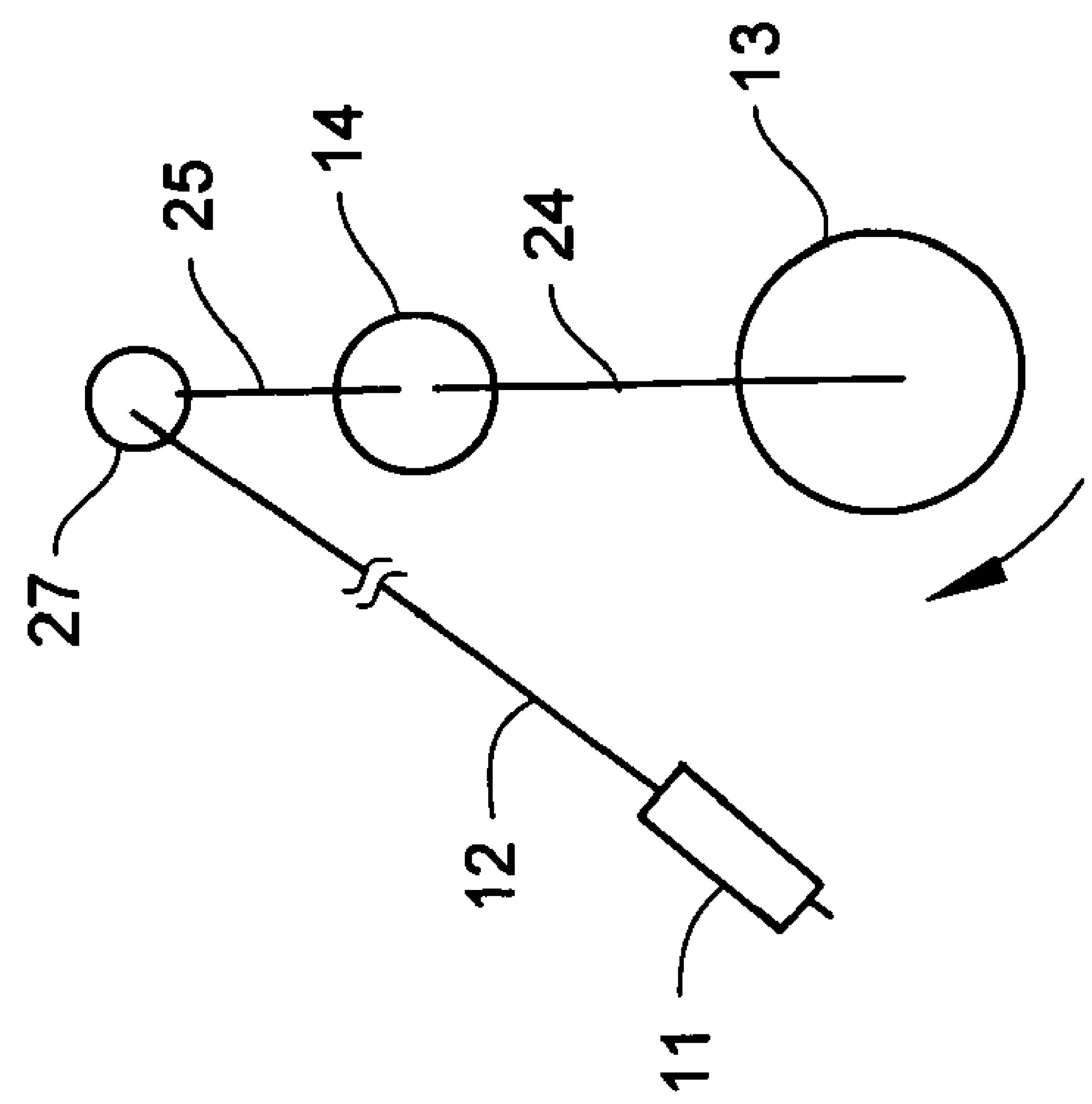

Fig. 10A

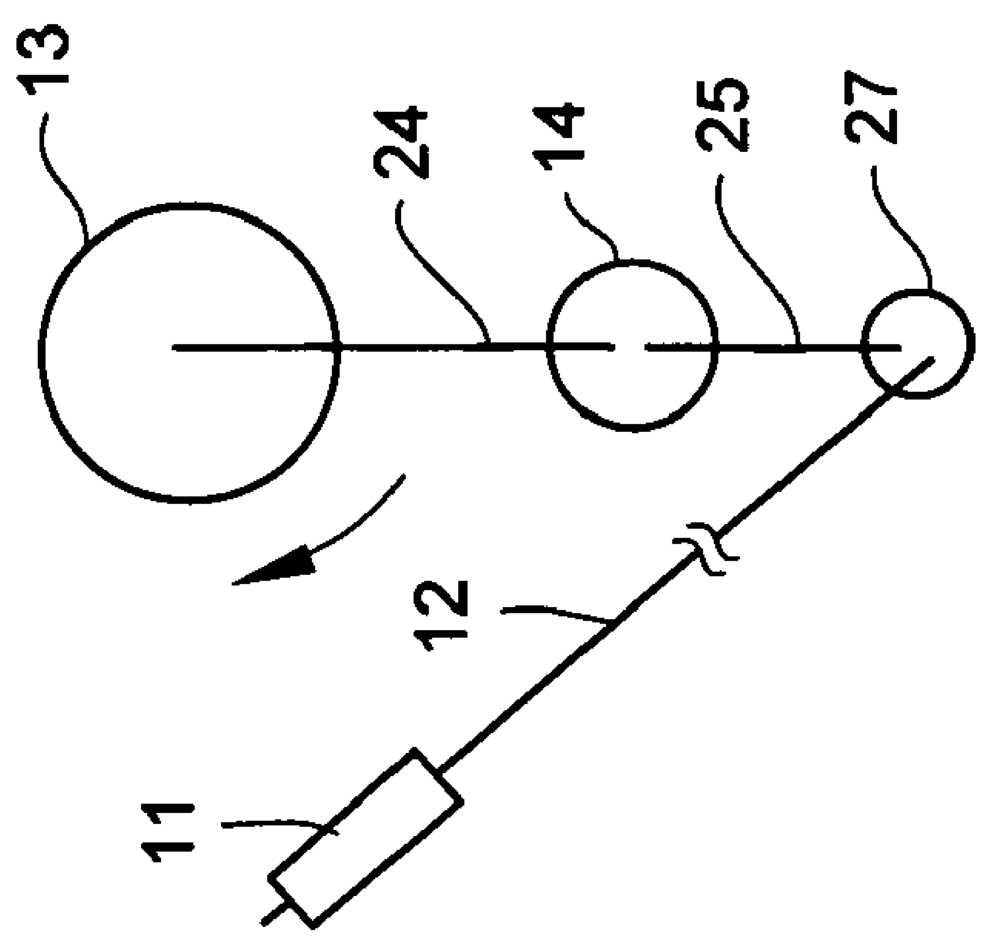

Fig. 10B

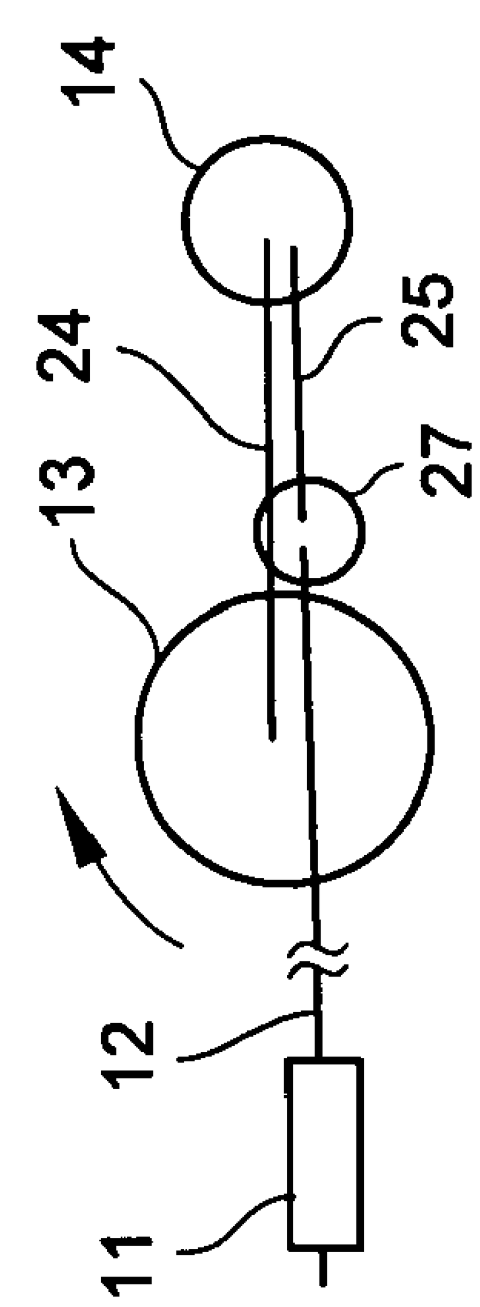

Fig. 11A

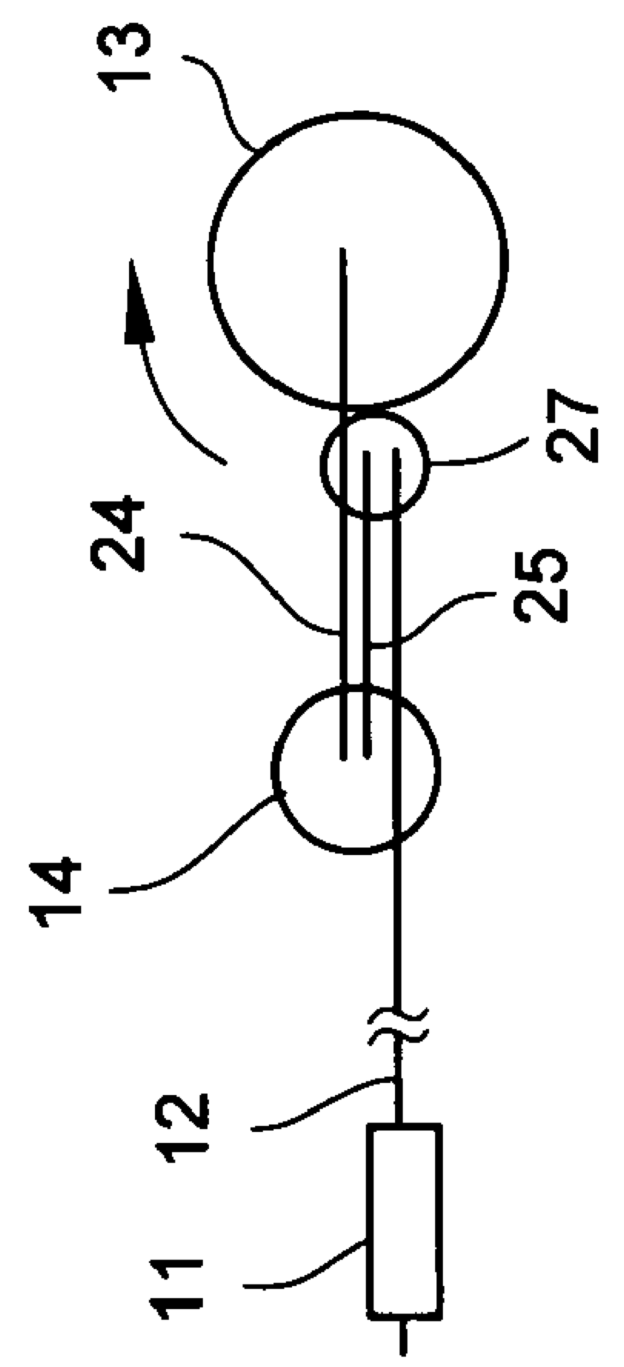

Fig. 11B

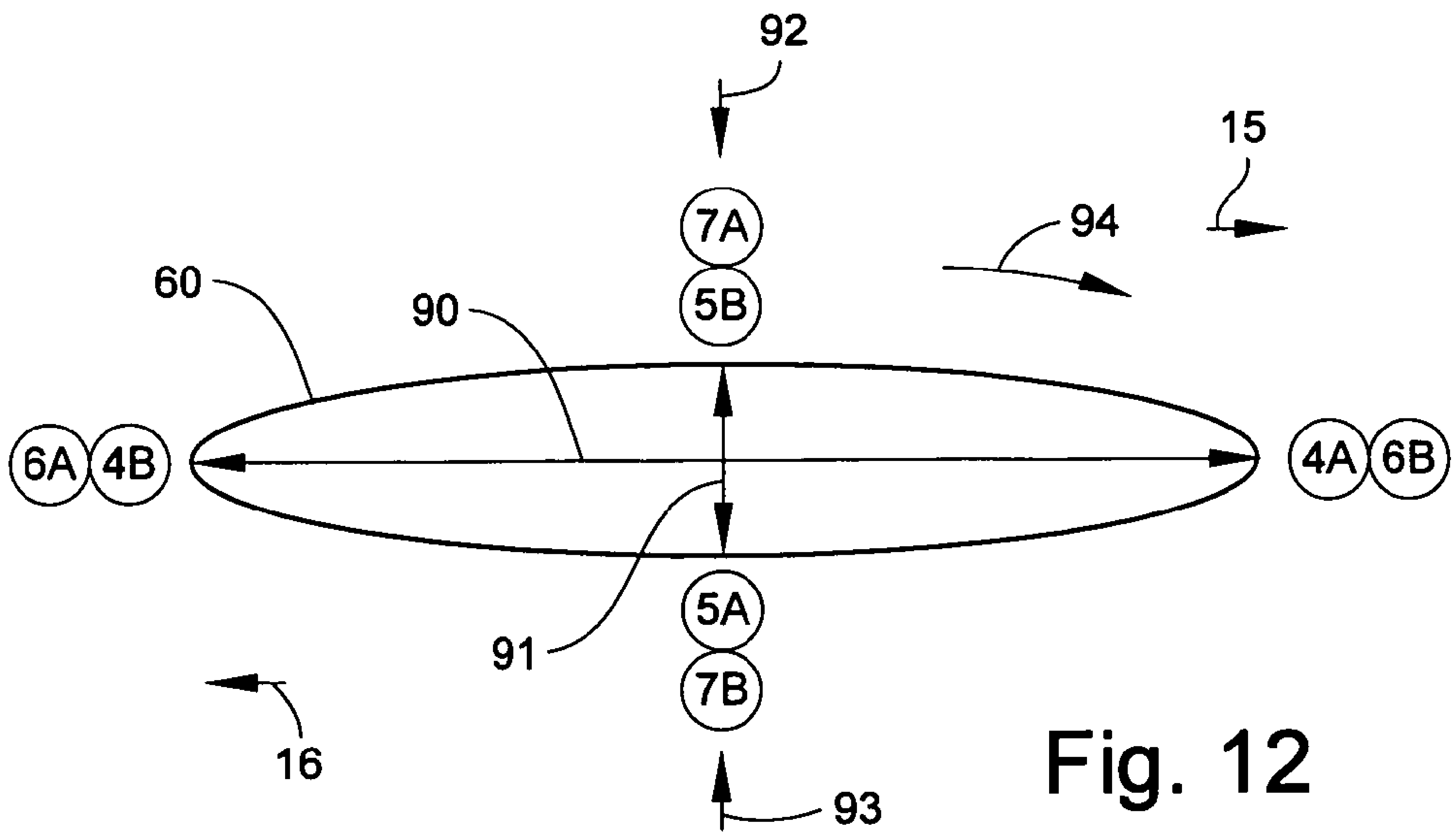
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Fig. 12

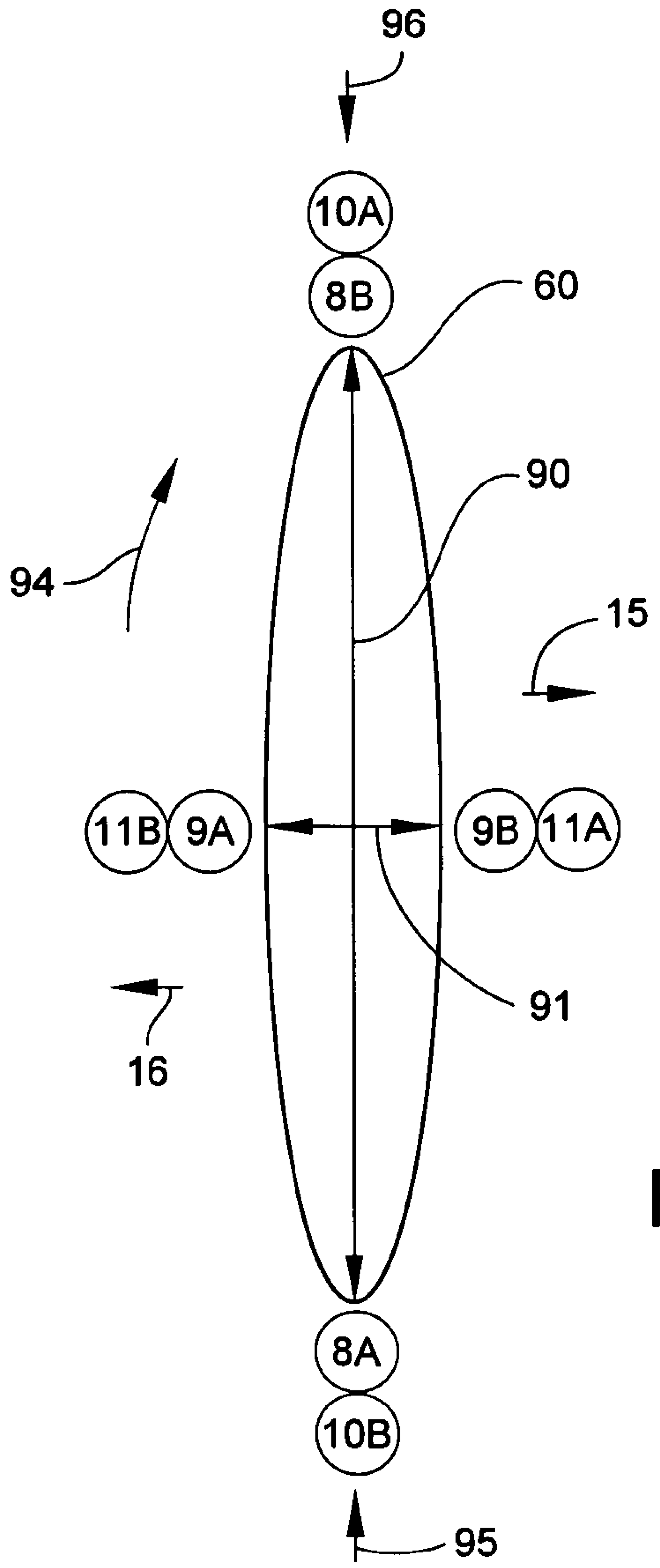
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Fig. 13

ELLIPTICAL EXERCISE DEVICE AND METHODS OF USE

FIELD OF THE INVENTION

The present invention relates to an exercise device and methods of using an exercise device. Embodiments of the present invention are useful, for example, for changing the orientation of an elliptical exercise motion while using the device.

BACKGROUND OF THE INVENTION

The benefits of regular exercise are well documented. To facilitate regular exercise, a number of exercise and fitness machines are now available for both commercial and in-home use. One of the more recently developed fitness machines is the so-called elliptical trainer. Elliptical exercise machines comprise various mechanisms to create a more or less elliptical exercise path for the user that provides the benefits of walking or running on a treadmill while reducing impact stress on the user's joints, such as the knees and hips.

Conventional elliptical exercise machines provide elliptical pedal motion by virtue of various reciprocating members and geared linkage systems. For example, elliptical pedal motion can be generated by a pair of foot pedal members driven on one end by a bicycle-type wheel, or bell crank, about a pivot axis. The pedal members can be guided on the other end by swinging arms or by being slidingly or rollingly engaged with a linear track or ramp. The wheel allows the foot pedals to move in upward and downward directions, while the slide or roller configuration allows the pedals to move in forward and backward directions. Such configurations result in a reciprocating, pseudo-elliptical exercise path and limit the range of exercise motion to the fixed circular guide path of the wheel or crank.

If the user of a conventional elliptical exercise machine is standing in an upright position, the exercise motion is generally in the form of a horizontal ellipse, such that the major axis of the ellipse is in the horizontal plane. It may be desirable to change the orientation of the exercise motion to provide a variety of "uphill" and "downhill" motions in an exercise program. In some conventional elliptical exercise devices, the orientation of the exercise motion ellipse cannot be changed from a preset orientation, such as an orientation in which the ellipse has a horizontal major axis.

Other conventional elliptical-type exercise machines allow for adjusting the orientation of the exercise motion. For example, a roller guide track that provides for generation of an elliptical path may be disengaged from one support position on a frame and re-engaged in another support position in order to change the exercise path. In another conventional elliptical exercise machine design, an upright support member connected to a bicycle wheel can be adjusted to allow for variable pedal motion.

One disadvantage of adjusting an elliptical exercise path in such conventional devices is that the adjustments often must be made manually. For a manual change of an elliptical exercise path, a user generally must stop use of the device, dismount the device, and physically move components of the device related to generation of an elliptical exercise path. Such manual changes to an elliptical exercise path can disrupt an exercise routine and may be so complicated or strenuous that users may opt not to make such changes, thereby defeating the purpose of having a device with an adjustable elliptical exercise path.

In a conventional elliptical trainer, a pedal can be attached to an arm on a planetary gear that is rotatable about a sun gear. The exercise path can be changed by moving the point of pedal attachment to discrete attachment points on the arm. By changing the point at which the user's foot exerts force on the planetary gear, the exercise motion of the planetary gear about the fixed sun gear can be changed. Such a means for changing the shape of an exercise motion has several disadvantages. In addition to the change having to be made manually, the change can only be made between the discrete, separated points of contact on the planetary gear arm. As a result, the exercise motions are limited to the orientations of an ellipse at those particular points of contact. However, it may be desirable to change an elliptical exercise motion to any orientation along a continuum between horizontal and vertical and to be able to provide those exercise motions in either an "uphill" or "downhill" orientation.

To alter an exercise path by achieving a longer stride, conventional elliptical cross trainers often use exaggerated pedal articulation. In elliptical-type exercise devices in which one end of a pair of pedal members rotates about a pivot axis and the other end is guided through a reciprocal path of travel, the angle formed by the user's ankles constantly changes between flexion and extension during the exercise cycle. Such conventional exercise devices that employ exaggerated ankle articulation and/or constant changes between flexion and extension have the disadvantage of potentially overworking a user's ankles.

SUMMARY OF THE INVENTION

The present invention provides elliptical exercise devices and methods for using an elliptical exercise device. Certain embodiments of the present invention are useful, for example, for automatically changing the orientation of an elliptical exercise motion along a continuum of orientations between horizontal and vertical. Such a change in exercise motion orientation can be made while maintaining a true elliptical exercise motion.

In one illustrative embodiment, the present invention provides an elliptical exercise device comprising a pair of pedal members, each of which is rotatably connected on one at least end to a pair of gears. The pair of gears can include a sun gear on each side of the device, an axle rotatably disposed through the sun gears, and a planet gear rigidly connected near each end of the axle for rotating about one of the sun gears. Each planet gear can be rotatably connected by a first link to one of the sun gears and by a second link to one end of a pedal member. Each of the pedal members can be rotatably connected to one of the planet gears. The pedal members and the planet gears are rotatable to provide an elliptical exercise motion. The embodiment can include a mechanism for simultaneously rotating each of the sun gears together to change the orientation of the elliptical exercise motion relative to a user.

The present invention can include embodiments of methods of using an elliptical exercise device.

Features of an elliptical exercise device and methods for making and using an elliptical exercise device embodiment of the present invention may be accomplished singularly, or in combination, in one or more of the embodiments of the present invention. As will be realized by those of skill in the art, many different embodiments of an elliptical exercise device and methods for making and using an elliptical exercise device according to the present invention are possible. Additional uses, advantages, and features of the invention are set forth in the illustrative embodiments discussed in the

detailed description herein and will become more apparent to those skilled in the art upon examination of the following.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an elliptical exercise device having a pair of sun gears and planet gears in both the front and the rear of the device in an embodiment of the present invention.

FIG. **2**A is a diagrammatic view of the positioning of the planet gears relative to the sun gears that results in an elliptical exercise motion having an uphill exercise orientation in an embodiment of the present invention.

FIG. **2**B is a diagrammatic view of the positioning of the planet gears relative to the sun gears that results in an elliptical exercise motion having a horizontal exercise orientation in an embodiment of the present invention.

FIG. **2**C is a diagrammatic view of the positioning of the planet gears relative to the sun gears that results in an elliptical exercise motion having a downhill exercise orientation in an embodiment of the present invention.

FIG. **3** is a perspective view of an elliptical exercise device having a pair of sun gears and planet gears in the front of the device in another embodiment of the present invention.

FIGS. **4**A/B-**7**A/B are diagrammatic views illustrating the relative positions of the sun gears, sun gear links, planet gears, planet gear links, pedal arm pivot rings, and pedals on the right side (FIGS. **4**A-**7**A) and on the left side (FIGS. **4**B-**7**B) of an elliptical exercise device at various points along a horizontal exercise motion ellipse in an embodiment of the present invention.

FIGS. **8**A/B-**11**A/B are diagrammatic views illustrating the relative positions of the sun gears, sun gear links, planet gears, planet gear links, pedal arm pivot rings, and pedals on the right side (FIGS. **8**A-**11**A) and on the left side (FIGS. **8**B-**11**B) of an elliptical exercise device at various points along a vertical exercise motion ellipse in an embodiment of the present invention.

FIG. **12** is a diagrammatic view illustrating the relative positions of the right and left side pedals illustrated in FIGS. **4**A/B-FIGS. **7**A/B along the major and minor axes of a horizontal elliptical exercise curve during an exercise cycle in an embodiment of the present invention.

FIG. **13** is a diagrammatic view illustrating the relative positions of the right and left side pedals illustrated in FIGS. **8**A/B-FIGS. **11**A/B along the major and minor axes of a vertical elliptical exercise curve during an exercise cycle in an embodiment of the present invention.

DETAILED DESCRIPTION

The present invention provides elliptical exercise devices and methods of exercising using an elliptical exercise device. Certain embodiments of the present invention are useful, for example, for automatically changing the orientation of an elliptical exercise motion along a continuum of orientations between horizontal and vertical. Such a change in exercise motion orientation can be made while maintaining a true elliptical exercise motion. FIGS. **1-13** illustrate embodiments of such an elliptical exercise device and methods.

An ellipse is defined as a plane curve, especially a conic section whose plane is not parallel to the axis, base, or generatrix of the intersected cone, or the locus of points for which the sum of the distances from each point to two fixed points is equal. (The American Heritage Dictionary of the English Language, Third Edition, 1996.)

As used herein, "exercise path," and "stride path" each refer interchangeably to the path, or curve, along which a user's feet move during an exercise cycle. "Exercise motion" refers to the movement of a user's feet along the exercise path, or curve, during an exercise cycle. In an embodiment of the present invention, the exercise motion can produce an exercise path, or curve, that is an ellipse. An "elliptical exercise path" is defined as a path of exercise motion along an elliptical curve and having a relatively longer first, or major, axis and a relatively shorter second, or minor, axis, which is perpendicular to the first axis. "Elliptical exercise motion" refers to the movement of a user's feet along an elliptical exercise path, or curve, during an exercise cycle. "Exercise motion ellipse" refers to the curve produced by elliptical exercise motion along an elliptical exercise path. Accordingly, as used herein with reference to an embodiment of the present invention, an "elliptical exercise path" refers to an elliptical path, or curve, along which a user's feet move during an exercise cycle. An elliptical exercise path or motion is referred to as horizontal when the longer, major axis is substantially parallel to the floor on which the exercise device is positioned and the minor axis is substantially perpendicular to the floor. An elliptical exercise path or motion is referred to as vertical when the longer, major axis is substantially perpendicular to the floor on which the exercise device is positioned and the minor axis is substantially parallel to the floor.

Referring to FIG. **1**, the elliptical exercise device **10** includes a pedal **11** connected to a pedal arm, or member, **12** on each side of the device **10**. The device **10** includes a pair of gears on both the forward **15** end and the rearward **16** end of the device **10**. Each pair of gears includes a sun gear **13** on each side of the device **10**. An rear axle **17** is rotatably disposed through the pair of sun gears **13** at the rear **16** of the device **10**, and a front axle **21** is rotatably disposed through the pair of sun gears **13** at the front **15** of the device **10**. Each pair of gears includes a planet gear **14** rigidly connected near each end of each axle **17**, **21**, respectively, for rotating about one of the sun gears **13**. Each pedal arm **12** is rotatably connected on each end to one of the planet gears **14** in each pair of gears.

The rearward **16** pair of gears is supported on a pair of rear vertical supports **18**, which extends upwardly from a frame **19**. The forward **15** pair of gears is supported on a pair of front vertical supports **22**, which extends upwardly from the frame **19**. The frame **19** is designed to rest on a floor surface and to provide structural support for the remaining components of the exercise device **10**. Each axle **17**, **21** is rotatably connected at the top of its respective vertical support **18**, **22** such that the sun gears **13** are rotatable on the tops of the vertical supports **18**, **22**.

The center of each planet gear **14** is rotatably connected with a rigid sun gear link **24** to one of the axles **17**, **21** at the center of one of the sun gears **13**. The planet gear link **25** can be rotatably connected to the planet gear **14** with, for example, a pin (not shown) fixed to the center of the planet gear **14** that extends through a bore in the end of the sun gear link **24** and then though a bore in the planet gear link **25**. The bores in the sun gear links **24** and the planet gear links **25** can include bearings or other means for enhancing rotation about the pin. A belt **28** operably engages the gears of each pair of sun gears **13** and planet gears **14** such that the planet gear **14** is rotatable about the sun gear **13** to which it is connected. Preferably, the sun gears **13** and planet gears **14** are configured to have teeth about the peripheral surface of the gears **13**, **14**. The belts **28** can include notches on the inner surface of the belts **28** that can engage the teeth of the gears **13**, **14**, so as to provide a smooth, positive rotation of the planet gears **14** about the sun gears **13**. The center of each end of the pedal arms **12** is rotatably connected with a rigid planet gear link **25** to the center of one of the planet gears **14**. Each end of the pedal arms **12** can include a pedal arm pivot ring **27** that is adapted to rotate about a pivot pin **26** extending outwardly from one end of the planet gear link **25**. The pedal arm pivot ring **27** can include bearings or other means for enhancing rotation about the pivot pin **26**.

Each planet gear **14** has a fixed rotatable relationship with one of the sun gears **13**. One of the sun gear links **24** rigidly connects the center of one of the planet gears **14** to the center of one of the sun gears **13**. The belt **28** provides a mechanism for further enhancing the smooth, positive rotation of each of the planet gears **14** about one of the sun gears **13**. As a result, the center of the sun gears **13** remains fixed with respect to the rotation of the planet gears **14** about the sun gears **13**.

The rotating motion of the sun gear links **24** provide the major axis of an exercise motion ellipse **60**, and the rotating motion of the planet gear links **25** provide the minor axis of the exercise motion ellipse **60** (as shown in FIG. **2**). Accordingly, rotation of the planet gears **14** about the sun gears **13** via the sun gear links **25** and rotation of the ends of the pedal arms **12** about the planet gears **14** via the planet gear links **25** provides an elliptical exercise motion.

In an embodiment, as shown in FIG. **1**, the exercise device **10** can further include a rear gear pulley **20** disposed about the rear axle **17** between the two rear vertical supports **18**. A front gear pulley **23** can be disposed about the front axle **21** between the two front vertical supports **22**. The two sun gears at the rear **16** of the exercise device **10** are fixedly connected to each other with the rear axle **17**. The two sun gears at the front **15** of the exercise device **10** are fixedly connected to each other with the front axle **21**. The rear gear pulley **20** and the front gear pulley **23** are fixedly connected to the rear and front axles **17**, **21**, respectively.

In a preferred embodiment, a timing belt **40** is rotatably engaged with the rear and front gear pulleys **20**, **23**, respectively. An idler gear **41** can be connected to the frame **19** near the center between the rear and front gear pulleys **20**, **23**, respectively. As shown in FIG. **1**, an idler gear support bracket **43** can be fixed to the frame **19**, and the idler gear **41** can be rotatably connected to the idler gear support bracket **43**. An idler gear axle **42** that extends from the center of the idler gear **41** through the idler gear support bracket **43** can be secured to the idler gear support bracket **43** with a washer **44** about the idler gear axle **42**. As shown in FIG. **1**, an embodiment can include two timing belts **40**. One of the timing belts **40** can be rotatingly engaged between the rear gear pulleys **20** and the idler gear **41**, and the other timing belt **40** can be rotatingly engaged between the idler gear **41** and the front gear pulley **23**. The timing belt(s) **40** serve(s) to help synchronize the timing of the rotation of the sun gears **13** at the rear **16** of the exercise device **10** with the rotation of the sun gears **13** at the front **15** of the device **10**.

In an embodiment, the pedals **11** and pedal arms **12** are in fixed relationship to one another, spaced-apart on the opposite, laterally outward sides of the front and rear vertical supports **22**, **18**, respectively. One pedal arm **12** and pedal **11** is phased opposite the other pedal arm **12** and pedal **11** by positioning the sun gear links **24** and planet gears **14** on the left side of the exercise device **10** at 180 degrees from the sun gear links **24** and planet gears **14** on the right side of the exercise device **10**. A such, the pedals **11** and pedal arms **12** travel along identical repeating elliptical paths, but 180 degrees out of phase with one another.

The exercise device **10** can be operated for exercise when a user's feet are placed in operative contact with the foot pedals **11**. The user exercises by striding forwardly (or rearwardly). As described, each pedal arm **12** is connected to the opposite side pedal arm **12** via the planet gear links **25**, sun gear links **24**, and axles **17**, **21**. The pedal arms **12** are positioned directly out of phase with each other. As a result, each striding motion of the user's feet on the foot pedals **11** pushes one pedal **11** and pedal arm **12** in one direction and the opposite pedal **11** and pedal arm **12** in the opposite direction.

Operation of the exercise device **10** can be started with the foot pedals **11** in any position. For example, with the exercise device **10** in the position illustrated in FIG. **1**, the user's weight placed predominantly on the right side pedal **11** causes the right pedal arm **12** to move downwardly. The gravitational force resulting from the user's weight being predominantly on the right side pedal **11** is transmitted to the right side pedal arm **12**, thus causing the right pedal arm **12** to rotate in the clockwise direction about the sun gears **13** (as viewed from the right side of the exercise device **10**). A natural striding motion causes the user to initially primarily ride the right pedal **11** downward but to push rearwardly **16** more with the right side pedal **11** as the user's right foot moves farther downward, much as the user would initially bring the foot into contact with the ground and then push backward against the ground while striding to propel the user forward. This movement on the exercise device **10** moves the right pedal arm **12** rearward **16**. As in a natural striding motion on the ground, as the right foot is moved rearward **16** to propel the user forward **15**, the user simultaneously moves the left foot forward **15** which helps carry the left side pedal **11** and pedal arm **12**.

In an embodiment of the present invention, the sun gears **13** can be rotated into different positions to change the orientation of the elliptical exercise motion relative to a user. In a preferred embodiment, the device **10** include can include a mechanism for simultaneously rotating each of the sun gears **13** together in order to change the orientation of the elliptical exercise motion. For example, as shown in the embodiment in FIG. **1**, the mechanism for simultaneously rotating each of the sun gears **13** together comprises a sun gear connector **33** rigidly connected to each of the sun gears **13** in at least one of the pairs of sun gears **13**. The sun gear connector **33** can be pivotally connected to a threaded collar **32**. The threaded collar **32** is engaged with and movable about a threaded rod **31** by rotating the threaded rod **31**.

The motor **30** can be actuated to rotate the threaded rod **31** so that the threaded collar **32** moves upward and downward along the threaded rod **31**. As the threaded collar **32** moves upward and downward, the sun gear connector **33** rotates the sun gears **13** a partial turn about the sun gear axis to change the orientation of the exercise motion relative to the exerciser. The motor **30** can rotate the sun gears **13**, for example, between about a ¼ turn and about a ⅜ turn, or a total movement of between about 45 and 135 degrees about the axis of the sun gears **13**. Thus, the mechanism for simultaneously rotating each of the sun gears **13** is adapted to rotate each of the sun gears **13** within about a 135 degree range. In the embodiment shown in FIG. **1**, the sun gears **13** are rotated at about 45 degrees above horizontal with respect to the sun gear connector **33**. Rotation of the sun gears **13** causes the exercise motion ellipse **60** to re-orient about a fixed point at the center of the sun gears **13**. Rotation of the sun gears **13** a partial turn rotates the sun gear links **24** a proportionate amount.

Although the motor **30** is positioned at the rear **16** of the exercise device **10** shown in FIG. **1**, the motor **30** can be positioned in operable connection with the pair of sun gears **13** at the front **15** of the device **10**.

An embodiment of the exercise device **10** of the present invention can change the orientation of an elliptical exercise motion dynamically from one orientation to another during a particular workout period. That is, the orientation of an elliptical exercise motion can be changed without interrupting the workout. In an embodiment, the point at which the pedal arms **12** can rotate about the planet gears **14** and the point at which the planet gears **14** can rotate about the sun gears **13** can remain fixed, and the orientation of the sun gears **13** can be changed in an automated manner, such as with actuation by the motor **30**. In this manner, an embodiment of the present invention avoids the disadvantages of conventional exercise machines that require manual movement of machine components to change the exercise motion. As a result, the shape of the exercise motion can remain constant, that is, a true ellipse, while the orientation of the exercise motion is changed with respect to the user. Thus, such a change in exercise motion orientation can occur dynamically to provide a change in workout intensity without interrupting exercise.

In an embodiment of the present invention, the exercise motion ellipse **60** can be re-oriented (or "tilted") to any degree along a continuum between horizontal and vertical. In a preferred embodiment, the rotation of the sun gears **13** is such that the sun gear (major axis) link **24** and the planet gear (minor axis) link **25** are rotated so as to move, or re-orient, the exercise motion ellipse in the range of about 70 degrees in either direction above and below horizontal. However, movement of the sun gears **13** such that the sun gear and planet gear links **24**, **25**, respectively, are moved to re-orient the exercise motion ellipse **60** more than about 45 degrees above or below horizontal creates an exercise motion orientation that is extreme and may be too difficult for many exercisers. For example, rotating the sun gears **13** such that the sun gear links **24** and planet gear links **25** are moved to re-orient the exercise motion ellipse **60** to approximately 90 degrees above or below horizontal, the exercise motion orientation becomes nearly vertical. That is, the exercise motion approximates stepping straight up or down (similar to climbing or descending a wall).

The rear axle **17** fixedly connects, or ties, the two rear sun gears **13** together. Likewise, the front axle **21** fixedly connects, or ties, the two front sun gears **13** together. In an embodiment, the exercise device **10** can include a mechanism for connecting the pair of front sun gears **13** and the pair of rear sun gears **13** together. For example, a front-rear tie rod **55** extends between and is fixedly connected to the rear axle **17** and the front axle **21**. Accordingly, when the motor **30** causes the rear sun gears **13** to rotate to change orientation of the exercise motion ellipse **60**, the front-rear tie rod **55** causes the front sun gears **13** to rotate the same direction and degree as the rear sun gears **13**. In this manner, all four sun gears **13** can be rotated simultaneously and identically, that is, in the same direction and in the same amount. The front-rear tie rod **55** can be a rigid material, such as steel. The front-rear tie rod **55** can be solid or can comprise a tubular shape. In an alternative embodiment, the front and rear sun gears **13** can be tied together by a front-rear tie rod **55** on each side of the device **10**. That is, a left front-rear tie rod **55** can rigidly connect the left front and rear sun gears **13**, and a right front-rear tie rod **55** can rigidly connect the right front and rear sun gears **13**. For example, as shown in FIG. **1**, the front-rear tie rod **55** can be rigidly connected to each of the front and rear main gears **13** with a tie rod-gear connector arm **56**. The tie rod-gear connector arms **56** can be formed from a steel bar or other material suitable for rigidly connecting the front-rear tie rod **55** and the sun gears **13**.

An embodiment of the present invention allows the elliptical shape of an exercise motion to be oriented to any degree along a continuum between horizontal and vertical. For example, as illustrated in FIG. **2**B, the exercise motion ellipse **60** can be located with the major axis being substantially horizontal and the minor axis being substantially vertical. As illustrated in FIG. **2**A, the sun gears **31** can be rotated so as to shift the sun gear links **24** in a clockwise direction, which creates an uphill orientation **61** of the exercise motion ellipse **60**, resulting in a user of the device **10** experiencing a sensation of going "uphill." Conversely, as illustrated in FIG. **2**C, the sun gears **13** can be rotated so as to shift the sun gear links **24** in a counter-clockwise direction, which creates an downhill orientation **63** of the exercise motion ellipse **60**, resulting in a user of the device **10** experiencing a sensation of going "downhill." These motion changes can be incorporated into an automated exercise program.

An embodiment of the exercise device **10** of the present invention allows the shape of the elliptical exercise motion to remain constant, or substantially constant, while the orientation of the elliptical exercise motion changes with respect to the user. That is, the orientation of the exercise motion can be changed from the major axis of the ellipse **60** being horizontal to the major axis of the ellipse **60** being vertical without moving through other exercise path shapes, such as circular or pseudo-elliptical. A "pseudo-elliptical" exercise path or motion is an exercise path or motion that may approximate an ellipse but includes discontinuities, such as "flat" spots, along its curve, as compared to a true mathematical ellipse. As a result, an embodiment of the present invention can provide an elliptical exercise motion that can be maintained as a true ellipse in each orientation of the exercise motion and while changing the orientation of the exercise motion. An exercise motion along a true elliptical curve provides a smoother, more natural, and comfortable exercise motion than other motion paths, such as a circular or linear exercise path, or pseudo-elliptical paths.

In another aspect of the present invention, when the sun gears **13** are rotated and the exercise motion ellipse **60** is oriented at an angle relative to the horizontal plane to provide an "uphill" or "downhill" exercise motion ellipse **61**, **63**, respectively, a user experiences no change in angulation at the ankle as compared to a horizontal elliptical exercise motion. That is, because the positions of the sun gears **13** of the exercise device **10** remain the same relative to each other when the orientation of the exercise motion ellipse **60** is changed relative to the user, foot-ankle articulation remains the same as in a horizontal exercise motion ellipse **62**. Accordingly, the user's feet remain substantially level on the pedals **11** while exercising in an "uphill" or "downhill" exercise motion ellipse **61**, **63**, respectively. A level orientation of a user's feet on the pedals **11** avoids the rearward **16** pressure on the user's feet from the physical movement upward of the front relative to the rear associated with conventional exercise devices to provide an actual "uphill" exercise motion. A level orientation of a user's feet on the pedals **11** avoids the forward **15** pressure on the user's feet from the physical movement upward of the rear relative to the front associated with conventional exercise devices to provide an actual "downhill" exercise motion. In this way, the user's feet remain positioned on the pedals **11** without rearward **16** or forward **15** pressures causing uncomfortable movement of the feet on the pedals **11** toward the rear **16** or front **16** of the pedals **11**.

Accordingly, an embodiment of the exercise device **10** can maintain a user's feet at a substantially constant angle, for example, substantially horizontal, relative to the floor while changing the orientation of the exercise motion and after the orientation is changed. As a result, the exercise motion produces minimal flexion and extension of the user's feet and thus minimal angulation between the user's ankles and feet. Eliminating or reducing overly flexed or extended angulation at a user's ankle joints during exercise prevents the user's feet from sliding forward **15** into the front edge of the pedals **11** when the exercise motion is in a "downhill" orientation **63** and from sliding rearward **16** into the rear edge of the pedals **11** when the exercise motion is in an "uphill" orientation **61**. Maintaining a user's feet at a substantially constant angle while changing the orientation of the exercise motion can reduce ankle strain and foot fatigue associated with other elliptical fitness equipment.

As shown in the embodiment in FIG. **1**, the exercise device **10** can include a flywheel connected to or integrally formed with the front gear pulley **23**. In an embodiment, a secondary front wheel **50** can mounted about a front wheel hub **51**. A front wheel support rod **52** can extend through the front wheel hub **51**, and can be supported by a front wheel vertical support **53** on each side of the device. The front wheel support rod **52** can be attached to the front wheel vertical support **53** with a cotter pin, bolt, or other suitable fastening means. The front wheel **50** is rotatably connected to the front gear pulley **23** with at least one front wheel belt **54**. The front wheel **50** can be configured to increase the speed of the flywheel and front gear pulley **23**. The flywheel, front gear pulley **23**, and front wheel **50** are preferably sufficiently heavy so as to help move the pedal arms **12** smoothly even when the user momentarily is not supplying a moving turning force to the pedals **11**.

In an embodiment, the exercise device **10** can include a load resistance mechanism (not shown). Such a load resistance mechanism can act to increase or decrease the resistance a user of the device **10** must overcome to move the pedal arms **12**. Load resistance can be changed in order to vary exercise intensity. The degree of resistance to the exercise motion may be input under user control to enhance the exercise experience. The load resistance mechanism may be connected to the front wheel **50**, axle(s) **17**, **21**, pulley(s) **20**, **23**, or other structures of the device **10**. The load resistance mechanism can be a weight secured to the exercise device **10** for applying a resistive force against movement of the foot pedals **11**. Alternatively, the load resistance mechanism can be provided with a braking mechanism, for example, magnetic resistance brakes, friction brakes, air brakes, hydraulic brakes, or other suitable braking mechanisms.

In an embodiment, the actuator, or motor **30**, can be connected to a control mechanism, which can include an electronic user interface device. Such a control mechanism can be housed in a control console **84**, which can be mounted on the handle support **82** (as shown in FIG. **3**). The control mechanism can include a user input device operably connected to the motor **30**. For example, an exerciser may change the orientation of the elliptical exercise motion by touching or otherwise interacting with a button, switch, knob, or other means on the control console **84** for signaling the motor **30**. The control mechanism may include a microprocessor to control the timing for actuating the motor **30** and the degree to which the sun gears **13** are rotated. The control console **84** can include a visual display, such as a LED display or other indicia, to indicate the level of change in elliptical exercise motion orientation. The electronic control panel can also provide other exercise related information as is conventional with exercise equipment.

The changes in orientation of elliptical exercise motion provided in an embodiment of the present invention can be pre-programmed prior to an exercise period. For example, the exercise motion ellipse can be programmed in a preset exercise program stored in a microprocessor to provide a variety of combinations of "uphill" and "downhill" orientations of the exercise motion ellipse. In this way, orientation of the exercise motion ellipse can be automatically changed during an exercise period and provide variable intensity exercise throughout the period.

In an embodiment of the exercise device **10**, arm exercise can be provided with handles (not shown) movably secured to the frame **19** or a structure connected to the frame **19**. For example, handles can be pivotally connected on one end to an upright handle support **82** (as shown in FIG. **3**) and pivotally connected on the opposite end with a coupling mechanism to one of the pedal arms **12**. When the user drives the pedals **11** and pedal arms **12** with foot and leg motion during exercise, the handles can move in coordination with the pedals **11** and pedal arms **12**. For example, when the left foot and pedal **11** are forward, the handle connected to the left side pedal arm **12** is rearward. At the same time in the exercise motion, the right foot and pedal **11** are positioned rearward **16** and the handle connected to the right side pedal arm **12** is forward **15**. Thus, an embodiment of the present invention can provide the operator with stable foot support through various orientations of elliptical exercise motion that can simulate walking, running, jogging, and climbing with very low joint impact as well as upper body exercise.

In an embodiment of the present invention, the exercise machine **10** can simulate striding-type motions from stepping in place with little or no stride length, such as with climbing, to running with large stride lengths. "Stride" is defined as the movement of the pedals substantially forward **15** and rearward **16** along the major axis of the exercise motion ellipse **60**. The stride length movements can match the natural movements of a user. "Stride length" refers to the distance between forward **15** and rearward **16** extents of travel of the user's foot during an exercise repetition. The stride length can be any length in a range suitable for humans as they walk or stride at other paces for exercise. For example, the stride length can be in the range of 18-28 inches, which accommodates typical stride lengths of persons having short legs and those having long legs. In a preferred embodiment, the stride length is between 22-24 inches, a typical stride length for many people.

The stride length can be adjusted by varying the total of the combined lengths of the sun gear link **24** and the planet gear link **25**. Because a stride moves forward **15** and backward **16** about a center point, the stride length (major axis) is twice the total of the combined lengths of the sun gear link **24** and the planet gear link **25**. For example, a total of the combined lengths of the sun gear link **24** and the planet gear link **25** of 12 inches provides a stride length, or major axis, of 24 inches.

"Rise" is defined as the movement of pedals substantially upwardly and downward along the minor axis of the exercise motion ellipse. The "rise" can be any height in a range suitable for humans as they move in an upward and downward stepping or striding exercise motion. For example, the rise height can be in the range of 0-12 inches. A zero inch rise, that is, no rise, is equivalent to stepping or moving on a horizontal surface without lifting one's feet from the surface, such as exercising on a ski-type exercise machine. In a preferred embodiment, the rise height is between 2 and 5 inches, a typical rise for many people during normal movement forward.

The rise height, or minor axis of the exercise motion ellipse **60**, can be adjusted by varying the relative lengths of the sun gear link **24** and the planet gear link **25**. The rise height, or minor axis, can be determined by first subtracting the length of the planet gear link **25** from the length of the sun gear link **24**. Because the rise of an elliptical exercise motion moves upward and downward about a center point (for example, a horizontal point), the rise height is twice the total of the difference between the lengths of the sun gear link **24** and the planet gear link **25**. For example, when both the sun gear link **24** and the planet gear link **25** have the same length, such as 6 inches, the rise height is zero ((6−6)=0×2=0). To determine the stride length in this embodiment, the total of the combined lengths of the sun gear link **24** (6 inches) and the planet gear link **25** (6 inches) is 12 inches, which provides a stride length of 24 inches (6+6=12×2=24).

In another illustrative embodiment in which the sun gear link **24** is 7 inches and the planet gear link **25** length is 5 inches, the rise height is 4 inches ((7−5)=2×2=4). In this embodiment, the stride length is twice the total of the combined lengths of the sun gear link **24** (7 inches) and planet gear link **25** (5 inches), or 24 inches (7+5=12×2=24). In another illustrative embodiment, the sun gear link **24** can be 7 inches and the planet gear link **25** length can be 4 inches, which creates a rise height of 6 inches ((7−4)=3×2=6), and the stride length is twice the total of the combined lengths of the sun gear link **24** (7 inches) and planet gear link **25** (4 inches), or 22 inches (7+4=11×2=22).

As shown in the embodiment in FIG. **1**, the exercise device **10** of the present invention can include a pair of sun gears **13** and planet gears **14** near both the forward **15** end and the rearward **16** end of the device **10**. In another embodiment, the exercise device **10** can include only one pair of sun gears **13** and planet gears **14**. In such an embodiment, a single pair of sun gears **13** and planet gears **14** can be located near either the forward **15** end or the rearward **16** end of the device **10**. FIG. **3** illustrates an embodiment having a single pair of sun gears **13** and planet gears **14**.

In the embodiment shown in FIG. **3**, the exercise motion orientation adjustment mechanism comprises a single pair of sun gears **13** and planet gears **14** preferably positioned near the forward **15** end of the exercise device **10**. Alternatively, the single pair of sun gears **13** and planet gears **14** can be positioned near the rear **16** end of the device **10**. The operation of the sun gears **13** and planet gears **14** in the embodiment in FIG. **3**, and the mechanism for simultaneously rotating each of the sun gears **13** together to change the orientation of the elliptical exercise motion relative to a user, are similar to the configuration and operation of the sun gears **13** and planet gears **14** and mechanism for adjusting an elliptical exercise motion in the embodiment in FIG. **1**.

As shown in the embodiment in FIG. **3**, the exercise device **10** can include a pair of pedal arms **12**, each of which is rotatably connected on one end to a pair of gears and connected on the other end to a pivot mechanism. The pair of gears can include the sun gear **13** on each side of the device **10**. The axle **21** can be rotatably disposed through the sun gears **13**, and one of the planet gears **14** can be rigidly connected near each end of the axle **21** for rotating about one of the sun gears **13**. Each of the pedal arms **12** is rotatably connected to one of the planet gears **14**. The pedal arms **12** and the planet gears **14** are rotatable so as to provide an elliptical exercise motion. The device **10** preferably includes a mechanism for simultaneously rotating each of the sun gears **13** together to change the orientation of the elliptical exercise motion relative to a user.

The center of each planet gear **14** is rotatably connected with a rigid sun gear link **24** to the axle **21** at the center of one of the sun gears **13**. The planet gear link **25** can be rotatably connected to the planet gear **14** with, for example, a pin (not shown) fixed to the center of the planet gear **14** that extends through a bore in the end of the sun gear link **24** and then though a bore in the planet gear link **25**. The bores in the sun gear links **24** and the planet gear links **25** can include bearings or other means for enhancing rotation about the pin. A belt **28** operably engages the gears of the pair of sun gears **13** and planet gears **14** such that the planet gear **14** is rotatable about the sun gear **13** to which it is connected. Preferably, the sun gears **13** and planet gears **14** are configured to have teeth about the peripheral surface of the gears **13**, **14**. The belts **28** can include notches on the inner surface of the belts **28** that can engage the teeth of the gears **13**, **14**, so as to provide a smooth, positive rotation of the planet gears **14** about the sun gears **13**. The center of one end of each of the pedal arms **12** is rotatably connected with a rigid planet gear link **25** to the center of one of the planet gears **14**. The ends of the pedal arms **12** connected to the planet gears **14** can include a pedal arm pivot ring **27** that is adapted to rotate about a pivot pin **26** extending outwardly from one end of the planet gear link **25**. The pedal arm pivot ring **27** can include bearings or other means for enhancing rotation about the pivot pin **26**.

Each planet gear **14** has a fixed rotatable relationship with one of the sun gears **14**. One of the sun gear links **24** rigidly connects the center of one of the planet gears **14** to the center of one of the sun gears **13**. The belt **28** provides a mechanism for further enhancing the smooth, positive rotation of each of the planet gears **14** about one of the sun gears **13**. As a result, the center of the sun gears **13** remains fixed with respect to the rotation of the planet gears **14** about the sun gears **13**.

The rotating motion of the sun gear links **24** provide the major axis of an exercise motion ellipse **60**, and the rotating motion of the planet gear links **25** provide the minor axis of the exercise motion ellipse **60** (as shown in FIG. **2**). Accordingly, rotation of the planet gears **14** about the sun gears **13** via the sun gear links **25** and rotation of the ends of the pedal arms **12** about the planet gears **14** via the planet gear links **25** provides an elliptical exercise motion.

As shown in the embodiment in FIG. **3**, the right and left side pedal arms **12** can each be pivotally suspended at its rearward **16** end from an upright support **18** by respective laterally spaced-apart right and left swing arms **70**. The swing arms **70** can be elongated, rigid links, such as metal tubes or rods. Alternatively, the swing arms **70** can be formed from flexible links, for example, made of cables, chains, straps, or another suitable flexible material. The upright support **18** extends upward from a fixed position on the frame **19**. The frame legs **81** extend laterally from the frame **19** to provide stabilization support of the exercise device **10** on a floor surface.

In the embodiment shown in FIG. **3**, each of the swing arms **70** is pivotally suspended about a fixed swing arm pivot rod **72** extending laterally from each side of the upright support **18**. One end of each swing arm **70** includes a swing arm pivot ring **71** that is pivotable about the swing arm pivot rod **72**. The swing arm pivot ring **71** may include rotary bearings and/or bushings to provide smooth pivoting of the swing arms **70** about the swing arm pivot rod **72**. The opposite end of each swing arm **70** is configured to pivotally connect to the rearward **16** end of one of the pedal arms **12**. In the embodiment in FIG. **3**, the rearward **16** end of each pedal arm **12** includes a coupler **73**. The end of each swing arm **70** opposite the end pivotally fixed to the upright support **18** is configured to pivotally fit within the coupler **73** on one side of the exercise device **10**. In alternative embodiments, the pivotable connections between the swing arms **70** and the upright support **18** on one end and the pedal arms **12** on the opposite end can have other suitable configurations.

Alternative mechanisms (not shown) for guiding movement of the rear portion of the pedal arms **12** can replace the assembly comprising the swing arms **70**, swing arm pivot ring

71 and rod **72**, and the coupler **73**. For example, the mechanism for guiding movement of the rear portion of the pedal arms **12** can include a roller mechanism connected to the pedal arms **12** that can roll forward and rearward on a pair of arched ramps.

The mechanism for simultaneously rotating each of the sun gears can include an elevation arm **74** rigidly connected to each of the sun gears **13**, a threaded nut **76** pivotally connected to the elevation arm **74** and threaded about an elevation rod **75**. The motor **30** is operably connected to the elevation rod **75** such that the motor **30** rotate the elevation rod **75** within the nut **76** to pivot the elevation rod **75** forward and rearward. In this way, the sun gears **13** can be simultaneously rotated.

The motor **30** and elevation rod **75** can be supported by a motor-elevation rod base **77**, which can be pivotally connected at base pivot **78** to the frame. The motor **30** can be actuated to move the sun gears **13** up or down, for example, between about a ⅛ turn and about a ¼ turn, or a total movement of between about 45 and 90 degrees, about a horizontal axis. As the elevation arm **74** and attached sun gear **13** are moved downward from the top **79** of the elevation rod **75**, the orientation of the resulting exercise motion ellipse **60** becomes gradually more vertical. As the exercise motion ellipse **60** becomes more vertical, the exercise motion becomes a correspondingly more "uphill" motion. For example, when the elevation arm **74** and nut **76** are positioned approximately half-way between the top **79** and the bottom **80** of the elevation rod **75**, the exercise motion ellipse **60** is oriented at about a 45 degree uphill angle.

An embodiment of the exercise device **10** of the present invention, as shown in FIG. **3**, for example, can change the orientation of an elliptical exercise motion dynamically, or automatically, from one orientation to another during a particular workout period without requiring manual movement of machine components to change the exercise motion. That is, the orientation of an elliptical exercise motion can be changed without interrupting the workout. As a result, the shape of the exercise motion can remain constant, that is, a true ellipse, while the orientation of the exercise motion is changed with respect to the user.

In the embodiment shown in FIG. **3**, the exercise motion ellipse **60** can be re-oriented to any degree along a continuum between horizontal and vertical. In a preferred embodiment, the rotation of the sun gears **13** is such that the sun gear (major axis) link **24** and the planet gear (minor axis) link **25** are rotated so as to move, or re-orient, the exercise motion ellipse in the range of about 70 degrees in either direction above and below horizontal.

The exercise device **10** shown in FIG. **3** can include a pair of handles **83** connected to the handle support **82**. The handles **83** can serve to assist the user in keeping balance during operation of the exercise device **10**. In an alternative embodiment, a means for support of the user's upper body can be configured as a handle bar or multiple handles (not shown) for grasping in different positions.

In the embodiment shown in FIG. **3**, the motor **30**, can be connected to a control mechanism, which can include an electronic user interface device. Such a control mechanism can be housed in the control console **84**, which can be mounted on the handle support **82**. The control mechanism can include a user input device operably connected to the motor **30**. For example, an exerciser may change the orientation of the elliptical exercise motion by touching or pushing on the control console **84** a button, switch, knob, or other means for signaling the motor **30**. The control mechanism may include a microprocessor to control the timing for actuating the motor **30** and the degree to which the sun gears **13** are rotated, and thereby create various workout programs.

FIGS. **4**A/B-**11**A/B illustrate the movements of rotatable components, including the sun gear links **24**, planet gears **14**, planet gear links **25**, pedal arm pivot rings **27**, and pedals **11** of the exercise device **10** through one elliptical curve **60** of exercise motion. During one elliptical curve **60** of exercise motion, the pedals **12**, for example, move from a starting point on the curve through the entire ellipse **60** back to that starting point. These illustrations depict the rotational movement during an exercise cycle of the planet gear **14** about its respective sun gear **13** and the rotational movement of the pedal arm pivot ring **27** about the planet gear **14** to which it is connected. FIGS. **4**A/B-**11**A/B illustrate movement in the clockwise direction **94**, which represents a user's forward striding motion during exercise. However, the pedals **11** of an elliptical exercise device **10** of the present invention can be moved by a user in a counterclockwise direction to create a rearwardly **16** directed exercise motion. In such a rearwardly **16** directed exercise motion, the movements of the rotatable components, including the planet gears **14** and the pedal arm pivot rings **27**, are the reverse of the movements illustrated in FIGS. **4**A/B-**11**A/B.

FIGS. **4**A-**11**A illustrate the relative positions of the sun gears **13**, sun gear links **24**, planet gears **14**, planet gear links **25**, pedal arm pivot rings **27**, and pedals **11** on the right side of the elliptical exercise device **10** at various points along the exercise motion ellipse **60**. Likewise, FIGS. **4**B-**11**B illustrate the relative positions of the sun gears **13**, sun gear links **24**, planet gears **14**, planet gear links **25**, pedal arm pivot rings **27**, and pedals **11** on the left side of the elliptical exercise device **10** at various points along the exercise motion ellipse **60**. In a preferred embodiment, the planet gears **14** and pedal arm pivot rings **27** on one side of the exercise device **10** are configured so as to be positioned, or phased, 180 degrees from the planet gears **14** and pedal arm pivot rings **27** on the opposite side of the exercise device **10**. Accordingly, the positions of the planet gears **14** and pedal arm pivot rings **27** on the right side of the exercise device **10** illustrated in FIG. **4**A are phased 180 degrees from the planet gears **14** and pedal arm pivot rings **27** on the left side of the exercise device **10** illustrated in FIG. **4**B. That is, when the components on the right side of the exercise device **10** are in the positions illustrated in FIG. **4**A, the respective components on the left side of the exercise device **10** are in the positions illustrated in FIG. **4**B. This same phased positioning of the planet gears **14** and pedal arm pivot rings **27** is illustrated in each of the companion drawings FIGS. **4**A-B through FIGS. **11**A-B.

In FIGS. **4**A-B through FIGS. **7**A-B, the exercise motion ellipse **60** produced by the illustrated clockwise **94** movements is horizontal. A horizontal exercise motion ellipse **62** (as shown in FIG. **2**B) is produced in the embodiment shown in FIG. **1** when the threaded collar **32** is positioned approximately half way up the threaded rod **31** such that the sun gear links **24** and the planet gear links **25** are both in horizontal position. A horizontal exercise motion ellipse **62** is produced in the embodiment shown in FIG. **3** when the elevation arm **74** and nut **76** are moved to the uppermost end **79** of the elevation rod **75** and the elevation rod **75** is pivoted toward the front **15** of the exercise device **10**.

As illustrated in FIG. **4**A, the right side planet gear **14** and pedal arm pivot ring **27** are each extended horizontally forward **15**, placing the right side pedal **11** in its forwardmost position in the horizontal plane (along the major axis **90** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **14** and pedal arm pivot ring **27** (FIG. **4**B) are each extended horizontally rearward **16**, placing the left side pedal **11** in its rearwardmost position in the horizontal plane (along the major axis **90** of the ellipse **60**). In this position, the right side and left side pedals **11** are at their greatest distance apart during the exercise cycle. As shown in FIG. **12**, in the positions illustrated in FIGS. **4**A and **4**B, the right side pedal **11** is located at one (or forward **15**) end of the major axis **90** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the opposite (or rearward **16**) end of the major axis **90** of the ellipse **60**.

FIGS. **5**A and **5**B represent the positions of the right and left side planet gears **14** and pedal arm pivot rings **27** after being rotated one quarter turn in the clockwise direction **94** (see FIG. **12**) about their respective sun gears **13** from the positions illustrated in FIGS. **4**A and **4**B. As illustrated in FIG. **5**A, the right side planet gear **14** is extended vertically downward and the right side pedal arm pivot ring **27** is extended vertically upward, placing the right side pedal **11** in a vertical and relatively downward position from the horizontal plane (along the minor axis **91** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **14** (FIG. **5**B) is extended vertically upward and the left side pedal arm pivot ring **27** is extended vertically downward, placing the left side pedal **11** in a vertical and relatively upward position from the horizontal plane (along the minor axis **91** of the ellipse **60**). In this position, the right side and left side pedals **11** are at the point of being closest together during the exercise cycle. As shown in FIG. **12**, in the positions illustrated in FIGS. **5**A and **5**B, the right side pedal **11** is located at bottom end **93** of the minor axis **91** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the top end **92** of the minor axis **91** of the ellipse **60**.

FIGS. **6**A and **6**B represent the positions of the right and left side planet gears **14** and pedal arm pivot rings **27** after being rotated one quarter turn in the clockwise direction **94** about their respective sun gears **13** from the positions illustrated in FIGS. **5**A and **5**B. As illustrated in FIG. **6**A, the right side planet gear **14** and pedal arm pivot ring **27** are each extended horizontally rearward **16**, placing the right side pedal **11** in its rearwardmost position in the horizontal plane (along the major axis **90** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **14** and pedal arm pivot ring **27** (FIG. **6**B) are each extended horizontally forward **15**, placing the left side pedal **11** in its forwardmost position in the horizontal plane (along the major axis **90** of the ellipse **60**). In this position, the right side and left side pedals **11** are again at their greatest distance apart during the exercise cycle. As shown in FIG. **12**, in the positions illustrated in FIGS. **6**A and **6**B, the right side pedal **11** is located at the rearward **16** end of the major axis **90** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the forward **15** end of the major axis **90** of the ellipse **60**.

FIGS. **7**A and **7**B represent the positions of the right and left side planet gears **14** and pedal arm pivot rings **27** after being rotated one quarter turn in the clockwise direction **94** about their respective sun gears **13** from the positions illustrated in FIGS. **6**A and **6**B. As illustrated in FIG. **7**A, the right side planet gear **14** is extended vertically upward and the right side pedal arm pivot ring **27** is extended vertically downward, placing the right side pedal **11** in a vertical and relatively upward position from the horizontal plane (along the minor axis **91** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **14** (FIG. **7**B) is extended vertically downward and the left side pedal arm pivot ring **27** is extended vertically upward, placing the left side pedal **11** in a vertical and relatively downward position from the horizontal plane (along the minor axis **91** of the ellipse **60**). In this position, the right side and left side pedals **11** are again at the point of being closest together during the exercise cycle. As shown in FIG. **12**, in the positions illustrated in FIGS. **7**A and **7**B, the right side pedal **11** is located at top end **92** of the minor axis **91** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the bottom end **93** of the minor axis **91** of the ellipse **60**.

The right and left side planet gears **14** and pedal arm pivot rings **27** can be rotated another one quarter turn in the clockwise direction **94** about their respective sun gears **13** from the positions illustrated in FIGS. **7**A and **7**B, back to their original positions illustrated in FIGS. **4**A and **4**B. Thus, FIGS. **4**A-B through **7**A-B represent the progression of movements of the sun gear links **24**, planet gears **14**, planet gear links **25**, pedal arm pivot rings **27**, and pedals **11** of the exercise device **10** through one horizontal exercise motion ellipse **60**.

In FIGS. **8**A-B through FIGS. **11**A-B, the exercise motion ellipse **60** produced by the illustrated clockwise **94** movements is vertical. A vertical exercise motion ellipse is produced in the embodiment shown in FIG. **1** when the sun gears **13** are moved such that the sun gear links **24** and the planet gear links **25** are both in a vertical position. A vertical exercise motion ellipse **60** is produced in the embodiment shown in FIG. **3** when the elevation arm **74** and nut **76** are moved to the lowermost end **80** of the elevation rod **75** and the elevation rod **75** is substantially perpendicular to the floor. While an exercise motion along a completely vertical ellipse may not be preferred by users for exercise, movement of components of the exercise device **10** along a vertical exercise motion ellipse **60** illustrates the range of elliptical exercise motions available in an embodiment of the device **10**.

As illustrated in FIG. **8**A, the right side planet gear **14** and pedal arm pivot ring **27** are each extended vertically downward, placing the right side pedal **11** in its downwardmost position in the vertical plane (along the major axis **90** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **14** and pedal arm pivot ring **27** (FIG. **8**B) are each extended vertically upward, placing the left side pedal **11** in its upwardmost position in the vertical plane (along the major axis **90** of the ellipse **60**). In this position, the right side and left side pedals **11** are at their greatest distance apart during the exercise cycle. As shown in FIG. **13**, in the positions illustrated in FIGS. **8**A and **8**B, the right side pedal **11** is located at the bottom end **95** of the major axis **90** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the top end **96** of the major axis **90** of the ellipse **60**.

FIGS. **9**A and **9**B represent the positions of the right and left side planet gears **14** and pedal arm pivot rings **27** after being rotated one quarter turn in the clockwise direction **94** about their respective sun gears **13** from the positions illustrated in FIGS. **8**A and **8**B. As illustrated in FIG. **9**A, the right side planet gear **14** is extended horizontally rearward **16** and the right side pedal arm pivot ring **27** is extended horizontally forward **15**, placing the right side pedal **11** in a horizontal and relatively rearward **16** position from the vertical plane (along the minor axis **91** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **27** (FIG. **9**B) is extended horizontally forward **15** and the left side pedal arm pivot ring **27** is extended horizontally rearward **16**, placing the left side pedal **11** in a horizontal and relatively forward **15** position from the vertical plane (along the minor axis **91** of the ellipse **60**). In this position, the right side and left side pedals **11** are at the point of being closest together during the exercise cycle. As shown in FIG. **13**, in the positions illustrated in FIGS. **9**A and **9**B, the right side pedal **11** is located at the rearward **16** end of the minor axis **91** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the forward **15** end of the minor axis **91** of the ellipse **60**.

FIGS. **10** and **10**B represent the positions of the right and left side planet gears **14** and pedal arm pivot rings **27** after being rotated one quarter turn in the clockwise direction **94** about their respective sun gears **13** from the positions illustrated in FIGS. **9**A and **9**B. As illustrated in FIG. **10**A, the right side planet gear **14** and pedal arm pivot ring **27** are each extended vertically upward, placing the right side pedal **11** in its upwardmost position in the vertical plane (along the major axis **90** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **14** and pedal arm pivot ring **27** (FIG. **10**B) are each extended vertically downward, placing the left side pedal **11** in its downwardmost position in the vertical plane (along the major axis **90** of the ellipse **60**). In this position, the right side and left side pedals **11** are again at their greatest distance apart during the exercise cycle. As shown in FIG. **13**, in the positions illustrated in FIGS. **10**A and **10**B, the right side pedal **11** is located at the top end **96** of the major axis **90** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the bottom end **93** of the major axis **90** of the ellipse **60**.

FIGS. **11**A and **11**B represent the positions of the right and left side planet gears **14** and pedal arm pivot rings **27** after being rotated one quarter turn in the clockwise direction **94** about their respective sun gears **13** from the positions illustrated in FIGS. **10**A and **10**B. As illustrated in FIG. **11**A, the right side planet gear **14** is extended horizontally forward **15** and the right side pedal arm pivot ring **27** is extended horizontally rearward **16**, placing the right side pedal **11** in a horizontal and relatively forward **15** position from the vertical plane (along the minor axis **91** of the ellipse **60**). When the right side planet gear **14** and pedal arm pivot ring **27** are in this position, the left side planet gear **14** (FIG. **11**B) is extended horizontally rearward **16** and the left side pedal arm pivot ring **27** is extended horizontally forward **15**, placing the left side pedal **11** in a horizontal and relatively rearward position from the vertical plane (along the minor axis **91** of the ellipse **60**). In this position, the right side and left side pedals **11** are thus again at the point of being closest together during the exercise cycle. As shown in FIG. **13**, in the positions illustrated in FIGS. **11**A and **11**B, the right side pedal **11** is located at the forward **15** end of the minor axis **91** of the exercise motion ellipse **60**, while the left side pedal **11** is located at the rearward **16** end of the minor axis **91** of the ellipse **60**.

The right and left side planet gears **14** and pedal arm pivot rings **27** can be rotated another one quarter turn in the clockwise direction **94** about their respective sun gears **13** from the positions illustrated in FIGS. **11**A and **11**B, back to their original positions illustrated in FIGS. **8**A and **8**B. Thus, FIGS. **8**A-B through **11**A-B represent the progression of movements of the sun gear links **24**, planet gears **14**, planet gear links **25**, pedal arm pivot rings **27**, and pedals **11** of the exercise device **10** through one vertical exercise motion ellipse **60**.

The present invention includes embodiments of a device adapted to change the orientation of an elliptical motion **60**. For example, such a device can comprise at least one pair of sun gears **13**, each of which is rigidly connected to the other sun gear **13** in the pair. The axle **17** or **21** can be rotatably disposed through each pair of sun gears **13**. The planet gear **14** can be rigidly connected near each end of each axle **17** or **21** for rotating about one of the sun gears **13**. The device can further include a pair of longitudinal members, each of which is rotatably connected on at least one end to one of the planet gears **14**. The longitudinal members and the planet gears **14** are rotatable to provide an elliptical motion **60**. The device can include a mechanism for rotating each of the sun gears **13** together to change the orientation of the elliptical motion **60** relative to a force exerted against the longitudinal members.

In one embodiment of a device adapted to change the orientation of an elliptical motion **60**, the mechanism for rotating each of the sun gears **13** can include the arm **74** rigidly connected to at least the sun gears **13** in one pair of sun gears **13** (as shown in FIG. **3**). The threaded nut **76** can be pivotally connected to the arm **64** and threaded about the elevation rod **75**. The actuator **30** can be operably connected to the elevation rod **75** and can pivot the elevation rod **75** by rotating the elevation rod **75** within the nut **76**, thereby rotating the sun gears **13**. In an another embodiment, the mechanism for rotating each of the sun gears **13** can include the sun gear connector **33** rigidly connected to at least the sun gears **13** in one pair of sun gears **13** and pivotally connected to the threaded collar **32** (as shown in FIG. **1**). The threaded collar **32** can be engaged with and movable longitudinally about the threaded rod **31** by rotating the threaded rod **31**, thereby rotating the sun gears **13**.

An embodiment of a device adapted to change the orientation of an elliptical motion **60** can include a first link, such as the sun gear link **24**, rotatably connecting each planet gear **14** to one of the sun gears **13** and a second link, such as the planet gear link **25**, rotatably connecting one end of each longitudinal member to one of the planet gears **14**. The first link and the second link each have a length. The length of the major axis **90** of the elliptical motion **60** comprises twice the combined lengths of the first and second links. The height of the minor axis **91** of the elliptical motion **60** comprises twice the difference between the lengths of the first and second links.

In an embodiment of a device adapted to change the orientation of an elliptical motion **60**, the planet gear **14** near one end of the axle **17** or **21** is positioned on the axle at 180 degrees from the planet gear **14** near the opposite end of the axle **17** or **21**. In an embodiment, the mechanism for rotating each of the sun gears **13** is adapted to rotate each of the sun gears **13** within a 135 degree range. In an embodiment, the orientation of the elliptical motion **60** be an elliptical motion that is oriented horizontal **62**, uphill **61**, or downhill **63** relative to a force exerted against the longitudinal members.

Embodiments of the present invention include methods of exercising. In a particular embodiment, a method of exercising can include using an elliptical exercise device **10** as described herein. For example, in an embodiment of a method of exercising, a user can access the exercise device **10** comprising a pair of pedal arms, or members **12**. At least one end of each of the pedal members **12** can be rotatably connected to a planet gear **14** on each side of the device **10**. Each planet gear **14** may be rigidly connected near each end of an axle **17**, **21**, and the axle **17**, **21** can be rotatably disposed through a sun gear **13** on each side of the device **10**. Each of the planet gears **14** can be rotated about one of the sun gears **13**. The pedal members **12** and the planet gears **14** can be rotated to provide an elliptical exercise motion. During exercise, the user of the device **10** can simultaneously rotate each of the sun gears **13** together to change the orientation of the elliptical exercise motion relative to the user.

In an embodiment of a method of exercise, each of the sun gears **13** can be simultaneously rotated together within a 135 degree range. In such an embodiment, each of the sun gears **13** can be simultaneously rotated together to change the orientation of the elliptical exercise motion to an orientation that is horizontal **62**, uphill **61**, or downhill **63** relative to the user. In another embodiment, the pedal members **12** can be maintained in a substantially horizontal plane when the sun gears **13** are simultaneously rotated together. In another embodiment, the exercise device **10** can include a handle pivotally connected to the forward **15** end of each of the pedal members **12**. The method can thereby include moving the pedal members **12** and the handles together during exercise.

In yet another embodiment, the exercise device **10** can include a control mechanism that can be actuated to control rotation of the sun gears **13** and the orientation of the elliptical exercise motion. The user may actuate the control mechanism during exercise to rotate the sun gears **13** and re-orient the elliptical exercise motion to a particular orientation desired during the exercise. Alternatively, the user may program a particular workout regimen prior to beginning exercise, or utilize a pre-programmed workout regimen, to automatically control rotation of the sun gears **13** and re-orient the elliptical exercise motion at pre-determined times and to pre-determined degrees during a workout period.

Embodiments of the present invention can be applied to devices and methods other than those involving fitness equipment. For example, other devices can include the configuration of at least one end of a pair of pedal members **12** rotatably connected to a planet gear **14** that is, in turn, rotatable about a sun gear **13**, in which the pedal members **12** and the planet gears **14** are rotatable to provide an elliptical exercise motion, and which includes a mechanism for simultaneously rotating each of the sun gears **13** together to change the orientation of the elliptical exercise motion relative to a user. Such a device may be utilized, for example, to change the orientation of motion of users gaining experience in an environment having less gravity than the earth. As another example, such a device may be utilized to change the orientation of motion for users in a health care or rehabilitation setting, without placing undesired stress on ankle joints and feet.

Although the present invention has been described with reference to particular embodiments, it should be recognized that these embodiments are merely illustrative of the principles of the present invention. Those of ordinary skill in the art will appreciate that an elliptical exercise device and methods for using an elliptical exercise device according to the present invention may be constructed and implemented in other ways and embodiments. Accordingly, the description herein should not be read as limiting the present invention, as other embodiments also fall within the scope of the present invention.

What is claimed is:

1. An exercise device, comprising:

a pair of pedal arms, each of which is rotatably connected on one end to a pair of gears and connected on the other end to a pivot mechanism comprising an upright support and a pair of swing arms, each swing arm pivotally suspended on one end about a side of the upright support and on the opposite end to one of the pedal members,

the pair of gears comprising a sun gear on each side of the device, an axle rotatably disposed through the sun gears, and a planet gear rigidly connected near each end of the axle for rotating about one of the sun gears,

each of the pedal arms rotatably connected to at least one of the planet gears,

the pedal arms and the planet gears rotatable to provide an elliptical exercise motion; and

a mechanism adapted to simultaneously rotate each of the sun gears together to change the orientation of the elliptical exercise motion relative to a user wherein the mechanism for simultaneously rotating each of the sun gears comprises an arm rigidly connected to each of the sun gears, a threaded nut pivotally connected to the arm and threaded about an elevation rod, and an actuator operably connected to the elevation rod for pivoting the elevation rod forward and rearward by rotating the elevation rod within the nut.

2. The exercise device of claim **1**, further comprising a first link rotatably connecting each planet gear to at least one of the sun gears and a second link rotatably connecting one end of each pedal arm to at least one of the planet gears.

3. The exercise device of claim **2**, the first link and the second link each comprising a length, wherein a stride length of the elliptical exercise motion comprises twice the combined lengths of the first and second links, and a rise height of the elliptical exercise motion comprises twice the difference between the lengths of the first and second links.

4. The exercise device of claim **1**, wherein the planet gear near one end of the axle is positioned on the axle at 180 degrees from the planet gear near the opposite end of the axle.

5. The exercise device of claim **1**, wherein the mechanism for simultaneously rotating each of the sun gears is adapted to rotate each of the sun gears within a 135 degree range.

6. The exercise device of claim **1**, wherein the orientation of the elliptical exercise motion comprises an elliptical exercise motion orientation that is horizontal, uphill, or downhill relative to the user.

7. The exercise device of claim **1**, wherein the mechanism for simultaneously rotating each of the sun gears is adapted to maintain the pedal arms in a substantially horizontal plane when the sun gears are rotated.

8. The exercise device of claim **1**, further comprising a handle pivotally connected to a forward end of each of the pedal arms.

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